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ABSTRACT

This document consists of three sections. Section I contains 19 activities developed by master teachers for the Science World '84 summer science program. These activities focus on studies involving airplane controls, trash bag kites, computers, meteorology, compass orienteering, soils, aquatic ecosystems, bogs, and others. Objectives, materials needed, and procedures used are provided for each activity. Section II contains 47 activities used in the Science World '84 exploratorium. The exploratorium is a classroom filled with activities that students can complete individually. These activities (which can take anywhere from 1 minute to 1 hour to complete, depending on the nature of the activity) utilize content from the biological, physical, earth, and environmental sciences. Topics explored include endothermic and exothermic reactions, acceleration of steel balls, the greenhouse effect, conservation of mass, living cells as electrolytes, energy flow, lung capacity, and Pascal's rule. Each exploratorium activity includes a challenge (such as "Try to stick a pin in a balloon without breaking the balloon"), procedures, and list of materials needed. Section III is a list of all the master teachers and guest presenters who took part in Science World '84. (JN)

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FOREWORD

Two years ago, 40 students and 18 teachers participated in SCIENCE WORLD. This summer, nearly ten times that many visited the field station at Pigeon Lake where they asked questions, created hypotheses and shared a special kind of comradery. It is our hope that the impact of SCIENCE WORLD on science education in Wisconsin will extend beyond a one-week experience and beyond the limited number of participants which our resources can reach directly.

The participating students and teachers will certainly carry their excitement into their classrooms with them, and perhaps that spark will ignite in others an enthusiasm for science and the general sense of curiosity which is at the heart of all learning.

The purpose of this book is to help keep that flame alive by providing science teachers with a compilation of activities that invite students to question and explore. It is an engaging book - a book for both students and teachers, a book to be enjoyed.

Herbert J. Grover
State Superintendent

PREFACE

One of the most important components of SCIENCE WORLD '84 was the activities developed by the master teachers. In the weeks preceding the summer program the master teachers met on several occasions to brainstorm and develop the wide variety of activities used at SCIENCE WORLD '84. Some of these activities can easily be adapted for classroom use, others such as the Lake Superior trip would be rather difficult to adapt! It is our hope that this book will provide you with ideas for activities in your own classes. It certainly is not a complete science curriculum and it would be inappropriate to use this as a replacement for the science curriculum you presently are using. However, it can provide an excellent supplement to your science program.

This book is divided into three sections. The first section includes the group activities developed by the master teachers. The second section includes the activities used in the exploratorium. The exploratium was a classroom filled with activities that the student could complete individually. The activities could be completed in as little time as one minute or in some cases take as long as an hour. They covered just about every field of science including physical, life, earth and environmental. The third section includes lists of all the master teachers and guest presenters who took part in SCIENCE WORLD '84.

If you have questions on any of the activities, feel free to contact the teachers who developed the activity. The list of presenters may be helpful to you in locating guest speakers for your own classes. I truly hope these activities will be useful to you, and if I can be of any help please contact me at the Department of Public Instruction, P.O. Box 7841, Madison, WI 53707. My telephone number is 608/267-9270.

Steve Sandstrom
Director
SCIENCE WORLD '84

SECTION I

Activities Designed By

SCIENCE WORLD Master Teachers

BEST COPY AVAILABLE

AIRPLANE CONTROLS AND HOW THEY WORK

Carol Pollard

OBJECTIVE:

To discover how airplane controls work.

MATERIALS:

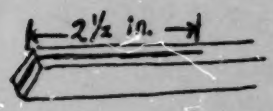
- 1 balsa stick (3/16" x 3/8" x 36")
- 1 flat balsa wood piece (1/16" x 3" x 36")
- airplane pattern sheet (attached)
- propeller
- wood glue
- 4 map tacks
- 12" Competition rubber for propeller
- 1 3" light weight rubber band
- 1 paper clip
- pliers that cut wire
- Exacto knife or razor blade
- ruler
- coping saw
- 10 small, thin straight pins

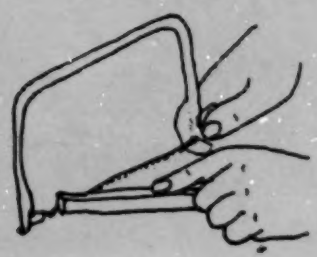
PROCEDURE:

You will need to very carefully follow the written directions on the pattern sheet and in the direction sheet. As you assemble your plane, think about the skills you are learning.

Step 1: Building the Body

Cut an 11" piece from the balsa stick. Use a ruler to get your measurement exact. Place the balsa stick on a flat, sturdy surface. Mark a 2½" line on the narrow slide at one end of the stick. Carefully cut a 2½" slit along the line with a coping saw. Observe the diagram below to help you do this correctly.



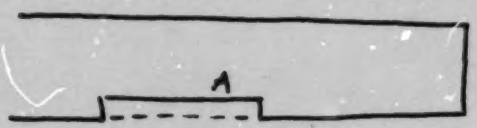


Step 2: Cutting Out the Wings

Cut the wings from the large, flat sheet of balsa. First, carefully cut the patterns from the pattern sheet, unless otherwise directed by your teacher. Lay the pattern on the balsa surface. Make all lines on the wood. Cut along the outside lines with a sharp-edged tool.

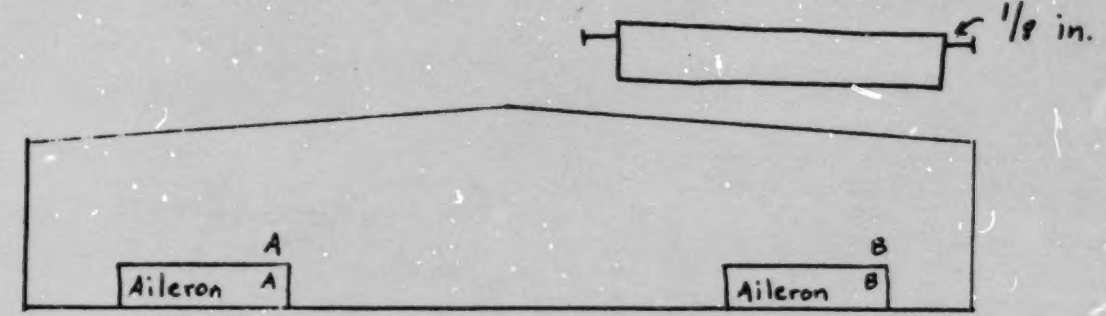
Step 3: Making Moveable Ailerons

You will need to mark each aileron so you can put it back in the same place after you cut it out. (You could use x, y, z.) Carefully cut the ailerons from the wing. Refer to the diagram below and the pattern sheet.



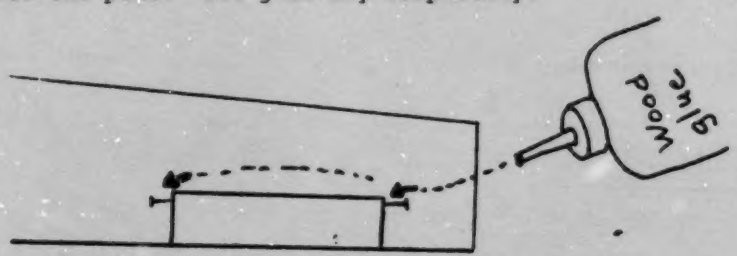
1. Get four straight pins.

2. Gently push two of these pins into the inside edge of the aileron. They should be about 1/8" away from the edge. This must be done carefully, as the balsa will split if forced. Observe the diagram below for help.



3. Repeat procedure #2 for the second aileron.

4. Replace the ailerons in their proper positions in the wings. Gently but firmly press the pins so they will mark where they will fit into the wing. Remove the ailerons, and make an indentation with your pencil so the pins will lay flat into this groove. With the ailerons back in position, put the wood glue over the pins. Let glue dry completely.

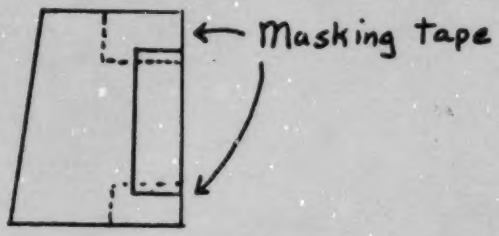


Step 4: Rear Wing

Make a paper pattern for this wing the same way you did for the forward wing. Cut out the rear wing. Cut out the elevators. Get four straight pins. Mount and glue the elevators in place as you did for the ailerons. Allow glue to dry completely.

Step 5: Vertical Stabilizer

Make the pattern for the stabilizer and place it on the balsa. Cut it out. When you cut the rudder from this piece, use extreme caution, as the stabilizer has a tendency to split. This can be stopped somewhat by placing a piece of masking tape at the top and the bottom of the stabilizer and making the cut for the rudder through the tape. Remove the tape very carefully so as to not break the stabilizer.



Push the pins into the rudder as you have done for the ailerons and the elevators. Lay the rudder on the stabilizer and mark its position. Make the groove and glue in the rudder.

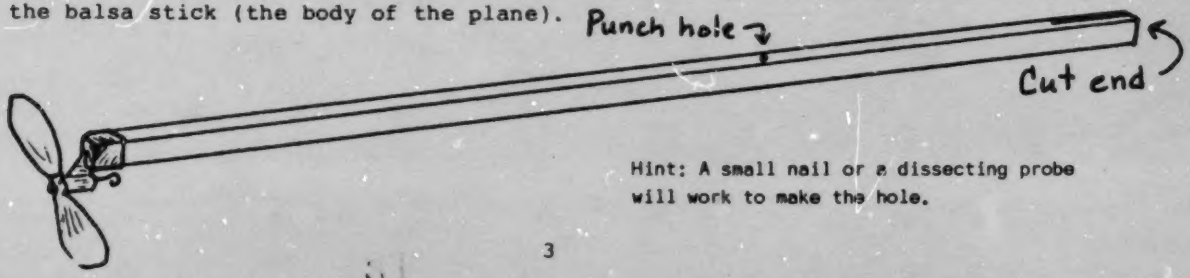
Step 6: Making the Plane Stronger

When you have completed the front wing, the rear wing, and the stabilizer you should cover the leading edges and exposed outer edges with a coating of wood glue. Do the top first, allow to dry completely, then do the bottom. Extreme care must be taken to be sure that none of the glue gets into the cuts you have made for the moveable ailerons, elevators, or rudder. If it does, these parts will no longer be moveable.

Step 7: Mounting the Propeller Assembly

Try to slide the plastic cap of the propeller over the end of the balsa stick that has not been cut. Do not force. Sand lightly until it fits on smoothly but snugly.

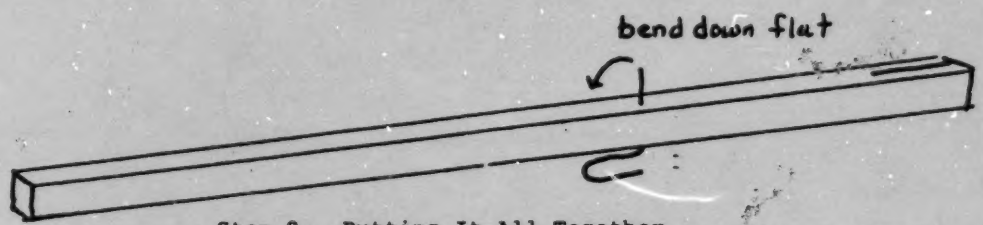
Mark a spot 4" from the cut end of the stick. Carefully punch a hole through the balsa stick (the body of the plane).



Hint: A small nail or a dissecting probe will work to make the hole.

Unbend a paper clip so it will look like the diagram below. Cut the large curved portion away.

Poke the straight wire of the paper clip through the hole in the body of your plane. The curved part of your paper clip will be on the bottom of the plane and will be used to hold the end of the rubber band from the propeller. The wire that is above the body of the plane should be carefully bent forward toward the propeller. Try to get it flat to the body. Use your pliers carefully. Wrap masking tape twice around the body to hold the paper clip firmly in position. Tie a knot in the long piece of rubber near the end. This can now be attached to the propeller and the bent paper clip.

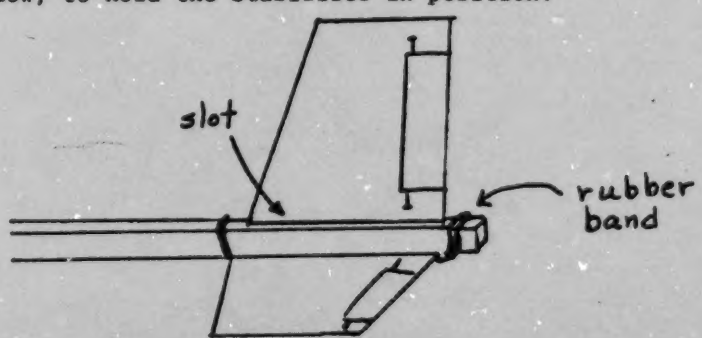


Step 8: Putting It All Together

Glue the rear wing to the underside of the body, 1" from the cut end. Use wood glue and two map tacks. The map tacks will be used to hold the wing in position until the glue has dried. You are then to remove the map tacks.

Put the stabilizer into the slot in the body. It should be moved as far forward as possible so that at least 1/4" of space is left at the rear of the body.

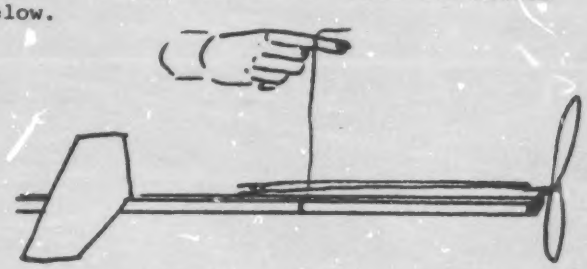
A small rubber band should be wrapped around the end of the body, as shown in the diagram below, to hold the stabilizer in position.



A small amount of glue should be placed along the body and the stabilizer so that the stabilizer is held firmly in position. Care should be taken to assure that the stabilizer is in a vertical position before gluing.

Step 9: Front Wing Placement

For your plane to fly well, the front wing must be in the correct position. If the wing is mounted properly, your plane will be balanced. Find the center of your wing as shown in the diagram below.



Find the center of gravity of the body of your plane by hanging it from a string and moving the string until you find the point where the airplane body balances. Mark this point. The center of the wing and the center of gravity of the body should be matched. Mount your wing on the top of the body with two map tacks. Glue the wing into position, making sure it is at a right angle to the body of the plane. Allow the glue to dry completely before flying the plane.

Step 10: Fly Your Plane

1. By turning the propeller, wind the rubber band motor 50 turns for your first trial flight.

2. To launch the plane, hold it at shoulder height, tilt the nose slightly upward, and give it a gentle push.

3. Your classroom is not large enough to test your plane. You should do this in a gym, or outside on a windless day.

4. Adjust the ailerons and stabilizer by moving them up or down to achieve the type of flight you wish. Experiment with each to find out what it will cause the plane to do in its flight path. Try moving the rudder. What does this do to the plane's flight?

5. What adjustments to the controls will give you a long, straight flight?

6. What adjustments will cause the plane to fly the highest without crashing at the end of the flight?

7. How do you set the controls to make your plane turn to the right? To the left?

8. Can you set the controls of your plane to do a loop?

9. How far will your plane fly with 100 turns to the motor?

HELPFUL HINTS TO KEEP IN MIND!

1. Move away from any objects into which your plane will crash.

2. Your plane will break if it hits any object too hard.

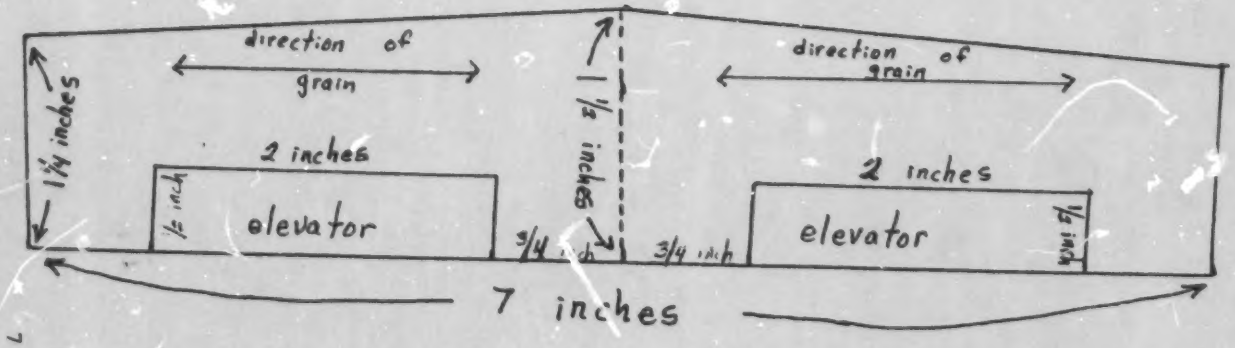
3. Repeated crashes may loosen the propeller mount. This will change the propeller angle. Care must be taken to maintain a level propeller angle.

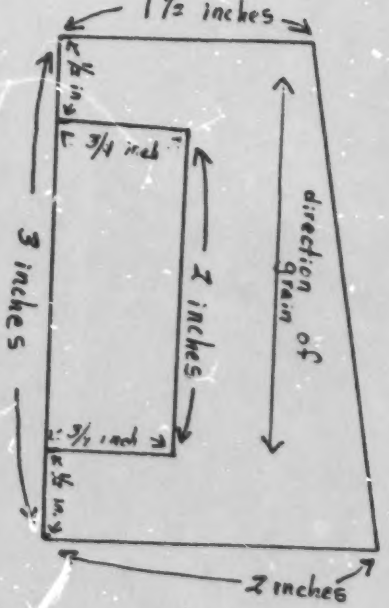
4. Winding your rubber band motor more than a full row of double twists will put too much stress on the body of the plane, and it could break.

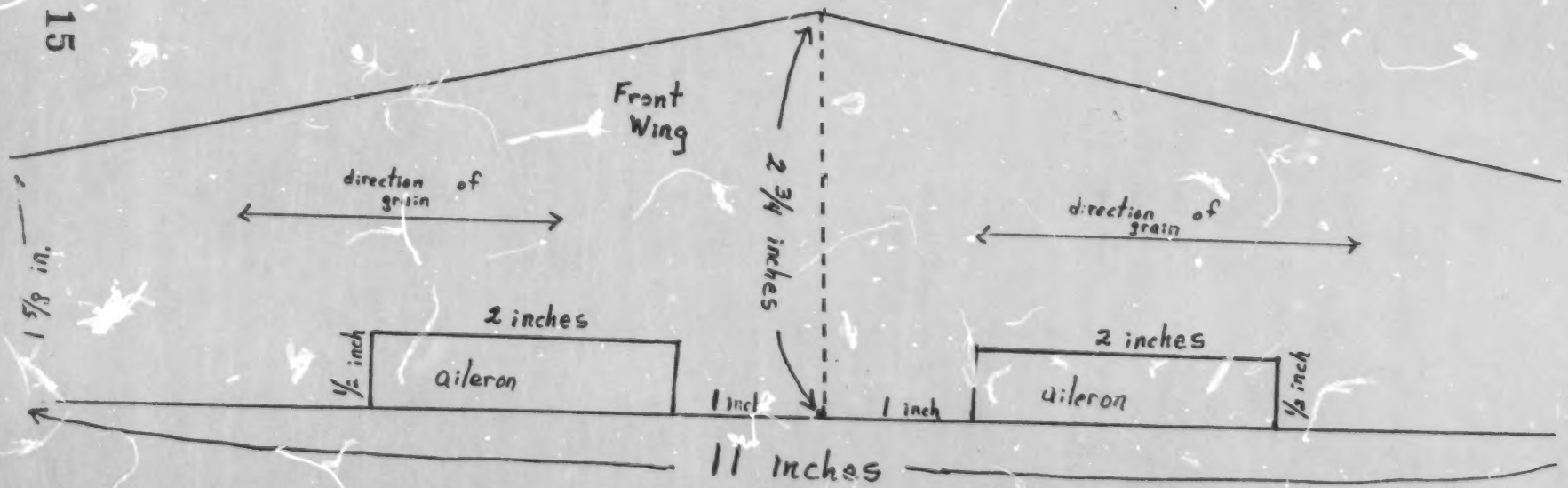
SUMMARY:

This is a problem-solving activity. Students should be encouraged to do the activity on their own. They should also be encouraged to explore the variable positioning of the ailerons, elevators, and rudder.

AIRPLANE PATTERN SHEET







TRASH BAG KITES

Rachel Egan

STUDENT OBJECTIVES

1. To follow a set of written directions.
2. To build and test fly a kite.
3. To use problem-solving skills to modify and improve the airworthiness of a kite after test flight.
4. To think about one application of science to leisure-time activities.

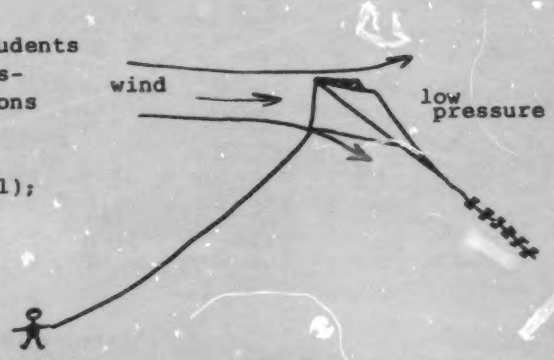
MATERIALS

trash bags (order from Kite Kraft - see summary)
strapping tape
dowels cut ¼" x ¼" x 36" from basewood
flying lines
rubber tubing (¼ I.D.)
plastic or rubber tubing (¼ I.D.)
fishing line swivels
scotch tape (for taping on designs)
bar soap (to make dowels slippery)
plastic straws (for strut pockets)
tools: exacto knives (to cut wood)
exacto blades
waterproof markers (to mark pattern and to decorate)
meter sticks
scissors
leather punch
long needles

PROCEDURE

Session #1 (2 hours)

A. Discussion (40 minutes). Find out what students know about kites and kite building in a discussion that includes the following questions and instructions.
   1. Who has flown a kite?
   2. What kind was it (size, shape, material); how well did it fly?
   3. How many of you have built a kite?
   4. What kind was it; how well did it fly?
   5. What is the first thing you want your kite to do? (lift)
   6. How does a kite fly? (See diagram).



7. What materials will you need to build a kite? Show students where materials are and introduce materials and terms, e.g.:
   a. sail
   b. reel-line
   c. dowel, spine, stick, strut, spar
   d. strapping tape.
   Introduce other terms and materials as you go along.
8. What type of kite do you want? Look over designs (see summary for sources of kite designs). Explain construction, wind, and flyability key (information on these can be found in _____).
9. Where will kites be tested? (Be sure to make arrangements for test flights.)
10. Each of you must put your name on a strut of your kite.
11. You must also give your kites names. Here are some suggestions.

Good names	Not so good
Red Rocket	The Rock
Sally Ride Special	Titanic
The Falcon	Nose Diver
Cloud Teaser	Crash

B. Allow one hour and 40 minutes for construction time.

Session #2 (2 hours)

A. Discussion (10-15 minutes)
   1. Is science only a career or can it be a hobby?
   2. Kite flying as a hobby
      a. kite competitions
      b. Kite Lines magazine
      c. Kites can lead to an interest in other activities:
         1. hang gliding,
         2. flying lessons,
         3. ballooning
         4. gliders
      d. Science and art can combine (show pictures of art kites that also fly.)
   3. Give out information on where to get materials for building art kites.

B. Construction (1 hour, 45 minutes)
   1. Tell students to try to have kites ready by _____ o'clock.
   2. Remind them to name their kites.
   3. Take students out to test fly kites.
   4. Have the students display kites in your classroom.

SUMMARY

1. Major resources
   a. Book - Kites: Aussie Style. The trask bag kite book by Wayne Hosking ($6.95), plans for more than 30 kites and variations.

   b. Store - Kite Kraft, School Haus Square, Frankenmuth, Michigan 48734
      Mailing address: 8028 Evergreen Park Drive, Saginaw, Michigan 48603
      Phone: (517) 781-3029
      (517) 652-2961 for book and colorful trash bags

c. Magazine - kite lines, 7106 Campfire Road, Baltimore, Maryland 21207.

2. There will be wide variability in completion times depending on:
   a. which design is chosen,
   b. how much decorating is done,
   c. students' ability to follow directions unaided.

3. Early finishers get more testing and flying time and can help others who have difficulty.

4. Build a few kites of different designs yourself or with 2-3 students to develop some personalized techniques and examples to show to your class.

5. Ten students is a good size group when offering all the designs.

6. For a larger group, 25-30, limit students to 3-5 kite designs.

7. It is nice to give each student his/her own flying line if possible. The most expensive ones come on cardboard tubes.

8. Make posters or overhead transparencies of the basic design choices to use during the initial discussion.

"AERO-RETARDATION" DEVICE

Myra Vachon

OBJECTIVE

To have students design and build an air-resistant device which will successfully land an uncooked egg (keep it from breaking) when dropped from an elevation of approximately 30 feet.

MATERIALS

FOR THE CONSTRUCTION PHASE: (2-hour time block for construction)
- variety of plastic fabrics (dry cleaner bags, garbage bags, visquen, etc.)
- plastic straws
- wooden sticks (kite stays)
- string
- wire
- wire cutters
- glue
- tape (masking and scotch)
- scissors
- magic marker

FOR THE TESTING PHASE: (1-hour time block for competition involving 30 devices)
- sandwich bags
- eggs
- hoisting device (can be a rod and reel with an automatic release or a long cord with a clip-type clothes pin)
- stopwatch

PROCEDURE

1. Introduce the challenge. If some students are familiar with the more common egg drop contest in which a container is designed to cushion the fall of an egg, ask one or two to tell about it. Explain that this challenge is different. Drawing from the name, "aero-retardation" device, ask a series of questions which will lead the students to understand that they are to build an air-resistant apparatus which will decrease the speed of the egg's fall. If the word "parachute" does not come up in the discussion, mention it; but caution the students not to restrict their thinking to the traditional shapes of parchutes. "Parachute" was purposely omitted from the title of the activity to avoid developing a certain mind set.

2. Present guidelines.
   a. Select materials from those provided.
   b. No dimension of the finished product may exceed 60 centimeters.
   c. The device must be designed so the egg will touch the ground first.
   d. A sandwich bag will be the only covering surrounding the egg.

e. Trials may be conducted during the building session to compare the air resistance of the parachutes. This will allow some time for modifications before the actual competition. (A sandwich bag with sand equalling the weight of the egg may be substituted for the raw egg.)

f. The competition will involve dropping the devices from approximately 30 feet off the ground. In addition to its ability to successfully land the egg, each device's dropping time will be used to determine the best "aero-retardation" designs.

3. Allow time for the teams to design and build their devices. As they finish, fill out a record sheet similar to the one below.

Number	Dropping Time	Device Name	Designers
1		The Scrambler	Peggy L & Kathy B
2		Free Fall	Kevin G & Clint H

4. Conduct competition. Using the record sheet, call out entries, clip each device to the rope or fishing line and drop from an elevation of 20 feet (second story window, stairwell, rooftop, etc.). Time each descent with a stopwatch and record. Identify the top five or ten designs.

SUMMARY

Students are usually very receptive to the challenge. During the building session, it is interesting to listen to team members "collaborating" and to watch as students modified their designs. Two things appear to be important. First, a variety of materials must be provided rather than limiting students to, for example, one kind of plastic or one kind of wire. Second, the teacher must avoid stifling creative designs by providing too much input. Encourage students to try out their devices during construction to see if an idea works or if changes are necessary. The rate of success was high because most of the eggs were not cracked upon impact; however, the falling times ranged from 1.55 to 4.88 seconds.

BUILDING A MOUSEMOBILE

Stephen Ring

OBJECTIVES

Using creative problem solving techniques, the learner will construct a "mousemobile" powered only by the spring of a mousetrap. It should be designed to travel at least three meters.

MATERIALS

- mousetraps
- string
- tape
- cardboard
- scissors
- glue
- rubber bands
- assortment of wheels
- axles
- popsicle sticks

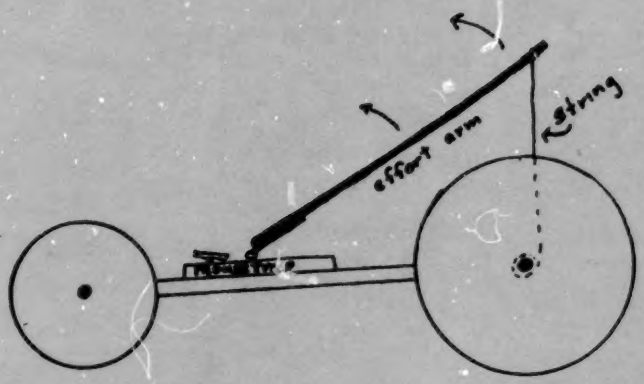
PROCEDURE

1. Allow the students to work in groups of two or three.
2. Depending on the amount of physical science background a student has, you may need to spend a fair amount of time covering some of the "basic" physical laws pertaining to forces, motion, effort, work, and energy. Note: Drive home the point that the greater the distance a force is applied the more work that is done.
3. Allow enough class time (4-6 hours) to complete the project.
4. Give the students a variety of materials and let them invent.
5. It is very important to allow the students to "figure it out" for themselves. Resist the temptation to lead them to the right answer. You are trying to develop thinking skills, not the perfect mousemobile.

SUMMARY

Many students will experience some frustration with the solution of such an open-ended activity. Assure them that there are many ways to solve the problem.

The key to solving the problem is to extend the effort arm or bar of the mousetrap. Wrap the string around the rear axle and fix it to the "extended" mousetrap bar. When the trap is sprung, the bar will pull the string, which in turn will pull the axle (to which the wheels are fixed) and hence the entire mousemobile.



You can, of course, provide your own restrictions. Some examples are listed below.

1. The mousetrap must be the only source of power.

2. The mousetrap must be a permanent part of the vehicle.

3. The mousetrap cannot be placed against a wall, book, or other immovable object.

4. No string or anything else can be taped to the floor.

5. The mousemobile must be completely self-contained.

SUSPENSION STRUCTURE CONTEST (Straw and Pin Bridge Contest)

Jackie Zukowski

OBJECTIVE

To build the suspension structure that holds the most weight.

MATERIALS

straws
pins
strap and small plastic pail or large cup (500ml)(to test bridge)
3-oz. lead sinkers or other weights
bridge stand

PROCEDURE

1. Introduce the idea of a suspension structure.

2. Give the students the following building restrictions or develop your own.
   a. The structure can be no longer than 30 cm.
   b. The structure can be no narrower than 10 cm. at any point.
   c. No more than 40 straws can be used.
   d. No more than 40 pins can be used.
   e. No other materials can be used.

3. The students work in groups of two and three.

4. The structures are tested by hanging a strap around each. A pail is attached to the strap. The 3-oz. sinkers are added one at a time. The weight just before the structure collapses is the recorded weight.

SUMMARY

It seems that when students are asked to build a "suspension structure" instead of a bridge, they produce a greater variety of designs. "Bridge" seems to limit students' creativity because of past exposure to bridges.

COMPUTER EXPERIENCE

Renn C. Karl

OBJECTIVES

After completing the computer activities, students will be able to:

a. operate the Apple IIe computer;
b. complete correctly the following simulations: ODELL LAKE, USPOP, PEST, NOMAD, ODELL WOODS, QUAKES, and TEXT-TRAIN;
c. Complete QUAKES and achieve a score of 100 km or less;
d. complete TEXT-TRAIN with the variable "Science";
e. understand a set of simple commands used for programming in LOGO;
f. create a simple graphics routine in LOGO graphics;
g. apply the "repeat" command to a simple LOGO graphics routine;
h. solve a LOGO programming problem;
i. complete a "Career Scan" using a computer; and
j. inquire into the function of a "Koala Pad," a "Mocking Board" synthesizer, a "science lab interface," a nuclear power plant simulator, a volcano simulation, and a graphics printer.

MATERIALS

HARDWARE: Apple IIe computer, monitor, and disk drive. OPTIONAL HARDWARE: graphics-capable printer, Koala Pad, HRM Science Interface, Mocking Board, and color monitor

SOFTWARE: MECC (Minnesota Educational Computer Consortium) Volumes I-IV, source of the programs Pest, USPOP, Nomad, Odell Lake, Odell Woods; and Quakes
Beagle Bros "Beagle Bag" for the program "Text-Train"
MECC disk 754 for the program "Heat-Loss"
WCIS (Wisconsin Career Information System) Career Scan
Terrapin LOGO
MUSE Three-Mile Island

PROCEDURE

This series of exercises is intended for a "laboratory" arrangement that provides one computer per student. Students will need six or more hours to complete the following activities.

(See attached activity sheets)

STUDENT ACTIVITY SHEET

THE RULES

1. No snacks, food, or drink.
2. Take only one disk at a time, if not using the station disks.
3. Handle disk only by the label.
4. Don't insert or remove a disk while the red disk drive light is on.
5. Don't put a disk on top of the disk drive.
6. Return each disk to its jacket and return it to its place of origin.
7. Don't "Pop" disk-drive latch; leave latch open when drive is not in use.
8. Games are allowed only during designated periods.

REQUIREMENTS

All students will complete a set group of computer-related activities. Listed below are required activities. (Teacher sign-off required before progressing to next activity.)

1. Introduction to the Apple IIe _____
2. Odell Lake _____
3. USPOP _____
4. Pest (same disk as USPOP) _____
5. Nomad (on Oregon disk) _____
6. Pigeon Woods _____
7. Quakes (Students must get within 100 km) _____
8. Text-Train (After completing the word "Science," record time.) _____

OPTIONAL ACTIVITIES

Students can do the optional activities only after completing the seven activities listed above.

1. Beagle Bros "Beagle Bag"
2. Oregon Trail
3. Volcano
4. Three-Mile Island
5. Logo
6. Mocking Board
7. Macintosh
8. Wiz Ware "Microzine"
9. Koala Pad
10. Heat-Loss
11. All programs not listed are considered optional.

COMPUTER ADAPTATIONS

THE RULES

1. No snacks, food, or drink.
2. Take only one disk at a time, if not using the station disk.
3. Handle disk only by label.
4. Don't insert or remove a disk while the red disk drive light is on.
5. Don't put a disk on top of the disk drive.
6. Place the disk in its jacket and return it to the proper area after use.
7. Don't "Pop" disk-drive latch; leave latch open when drive is not in use.
8. Games allowed only during designated periods.

REQUIREMENTS

During this session, students will be required to do certain things and given the opportunity to choose among others. (Teacher sign-off required before progressing to next activity.)

1. All students must program in LOGO. _____

2. All students must complete a Career Scan search. _____

3. If time permits, students are encouraged to choose from the following list of optional programs. _____

   ____a. Heat-Loss (If they choose this program, each may work with a partner; the program requires a computer with a printer.)
   ____b. Volcanoes
   ____c. Three-Mile Island
   ____d. Complete the Heart Rate experiment using a computer.

ADDITIONAL OPTIONS

Students can do these optional activities only after completing three of the required activities listed above.

1. Beagle Bros "Beagle Bag"
2. Oregon Trail
3. Volcano
4. Three-Mile Island
5. Logo
6. Mocking Board
7. Macintosh
8. Wis Ware "Microzine"
9. Koala Pad
10. Heat-Loss
11. All programs not listed above are optional.

SUMMARY

It was the intention of this teacher to present the computer as a "tool" to be used in science. SCIENCE WORLD '84 is not a "computer camp," and therefore programming in the traditional languages was not presented. Just as it is not necessary to be a mechanic in order to drive a car, it is this instructor's belief that it is not necessary to know how to "program" in order to use a computer. The presentation of LOGO language was done more to develop "formative" rather than programming skills.

During sessions of SCIENCE WORLD '84, students were scheduled for one four-hour block to complete the first set of activities. Later, students were scheduled into one two-hour block for the second set of activities. In most cases the time was sufficient. In a regular classroom more time might be needed.

If more time were available, I would like to see students more involved with equipment such as the LEAP SYSTEM, HRM SOFTWARE, and ADALAB. These materials allow the user to utilize a computer as a laboratory instrument.

It is this teacher's belief that the future of science education is intimately connected to the use of computers. I believe that as early as SCIENCE WORLD '85, we will see the use of a system called SCI-LAB which takes advantage of a computer-based technology known as "computer-interactive videodisc" or CIVD.

COMMUNICATIONS IN THE COMPUTER AGE

Al Hovey, Jr.

OBJECTIVES

Upon completion of this demonstration and discussion, the student should

a. know where AM, FM, etc. are on the radio spectrum;
b. be able to use a shortwave radio more effectively;
c. develop an understanding of the use of RTTY, SSTV, and satellites in today's communications;
d. see how alternate energy sources can be used to power a radio; and
e. know the procedure for obtaining an amateur radio license if they want one.

MATERIALS

1. amateur radio receiver and transmitter for the 2-, 80-, 40-, and 20-meter amateur bands attached to a simple antenna
2. QSL cards (verification of radio contact) from various countries and one blank card to hand out per student
3. handout on licensing procedures
4. solar panel (6v or 9v to power a portable radio)
5. chart of the radio spectrum

PROCEDURE

Use the hobby of amateur radio to teach students about radio communication as an introduction to the field of electronics.

A. Radio Spectrum (Use wall chart.)
   1. Elf, AM, cordless phones, amateur, CB, TV, FM, satellites, scanners
   2. Use the formula $\frac{468}{\text{freq. in Mhz.}}$ to figure antenna length (see summary).

B. Two-meter amateur demonstration
   1. Simplex FM
   2. Repeat operation with FM
   3. W5LFL STS9 Space Shuttle Columbia experience

C. Solar-powered radio demonstration

D. 0-30 Mhz. radio
   1. Shortwave and amateur reception
   2. Tune WWV on 5 Mhz. or 10 Mhz. (set watches).
   3. Explain use of amateur radio in the evacuation of medical students from the island of Grenada.
   4. Collect weather data each morning and call into National Weather Service on 3.985 at 6:00 a.m.
   5. Explain QSL cards (verification of radio contact and pass some around.

E. Licensing
   1. Go over amateur license structuring.
   2. Explain radio prefixes in different countries.

F. Types of communication in use:
   1. RTTY,
   2. SSTV,
   3. CW (show old morse key and new computer ones).

G. Make contacts on FM and SSB as time permits.

SUMMARY

While at Science World '84, students made 93 radio contacts with other amateurs in 18 states and three countries.

Laying out a long chart and telling the students to imagine they had a huge radio dial 10 feet long that would cover the radio spectrum worked well. Having the students attempt to figure antenna lengths (lower frequency, longer antenna) worked well.

Demonstrations of actual on-air contacts are very valuable but not always possible during the daytime. Many students and participating teachers came in at night for a better demonstration.

METEOROLOGY

Margie Dishno and Al Stawicki

OBJECTIVE

Familiarize students with some simple observations and measurements used in weather recording and forecasting. Students will measure and record weather data for one day and formulate a forecast.

MATERIALS*

weather data chart (one per student)
Beaufort scale (wind speed, one per student)
high-low thermometer (temp.)
helium balloons (wind direction)
barometer (barometric pressure)
sling psychrometer (relative humidity)
Sager Weather Forecaster
relative humidity chart

* items can be purchased from most of the scientific supply houses.

PROCEDURE

1. Introduction
   Meteorology is the study of weather.
   Teacher should give a sample weather forecast. Include basic components of a weather report and forecast (temperature, high-low, humidity, precipitation, etc.), but make it humorous (tall tale) and include old wives' tales about the weather. Discussion follows. Ask students to identify the needed information or data for a good forecast.

2. Hand out weather data charts.

3. Teacher then shows students various weather instruments and methods used to take weather data. Ask for student volunteers and have each one, or pair, collect one piece of weather information, e.g., wind speed.

4. Have the group disperse to collect data for 10-15 minutes.

5. Bring group back together to share results.

6. As a group, use the Sager Weather Forecaster to formulate a forecast for the next day. Pick three to five volunteers to give the forecast to the entire class.

COMPASS ORIENTEERING

Al Stawicki

OBJECTIVES

1. Develop students' skill in using a "Silva" compass.
2. Create an awareness of the camp's surroundings or of any other outdoor area.
3. Provide practice in observational and identification skills.
4. Develop cooperation between student-team units and groups.
5. Create problem-solving situations.
6. Provide the necessary skill to increase the enjoyment of such life sports as hunting, fishing, backpacking, snowmobiling, and cross-country skiing.

MATERIALS

15 type-3 Silva compasses
26 control markers (aluminum cans painted a fluorescent orange)
60 compass rose practice diagrams (see sample)
60 markers for creating geometric figures (wooden dowels about 18" long)
1 pacing course (a 200-foot, marked straight line for pacing practice)
1 pre-set schoolyard compass game practice course (see sample)
8 different student-team compass course instruction cards (see sample)

PROCEDURE

Introduction and Classroom Instruction

I. Parts of a Silva compass:
   a. magnetic needle,
   b. directional letters,
   c. 360° circle - 2° intervals,
   d. orienting arrow,
   e. direction of travel arrow.

II. Locating bearings
   a. Three-step procedure
      1. Set bearing.
      2. Align the orienting arrow and the magnetic north arrow.
      3. Follow the direction of the travel arrow.

Outdoor Practice Exercises

I. Determining distances
   a. "Pace" equals a double student step.

b. Students will walk a 200-foot pace line course back and forth, counting paces. Students then divide their total paces (double step) into 400 feet to determine their individual pace distances.

II. Pacing Out Geometric Figures with a Magnetic Compass (see sample)
   a. square, triangle, and hexagon
      1. pace and bearing

III. Silver Dollar Hunt
   a. three-legged compass walk
      1. 10 paces at 90°, 210°, and 330°
      2. Teacher should preset rewards (such as a quarter or piece of candy, etc.) for those students whose compass skill returns them to their original starting spot.

IV. Schoolyard Compass Game (see sample)
   a. The course consists of eight stakes placed at the same distance, but at different bearings, from a common center stake.
   b. Relay teams of five students are given instruction cards (see sample) requiring them to locate five preset bearings.
   c. Each bearing provides a lettered stake leading to a coded message.
   d. First relay team with the correct coded message wins the contest.

Major Orienteering Field Course

A teaching compass course may be used almost anywhere to help develop students' orienteering observational skills. Such courses are really interpretive trails using compass directions to get from point to point. Their features are:

1. teaching stations;
2. comments, questions, and activities at each station on what the learner is to observe, measure, do, or accomplish (see sample); and
3. directions leading learners from station to station (see sample).

The field course at Pigeon Lake consisted of 26 teaching stations asking a total of 47 questions. Students were divided into teams of two, and challenged by one of eight different field course instruction cards.

The course was developed to incorporate the natural and human-made features of the area, and to achieve the major objectives mentioned earlier.

SUMMARY

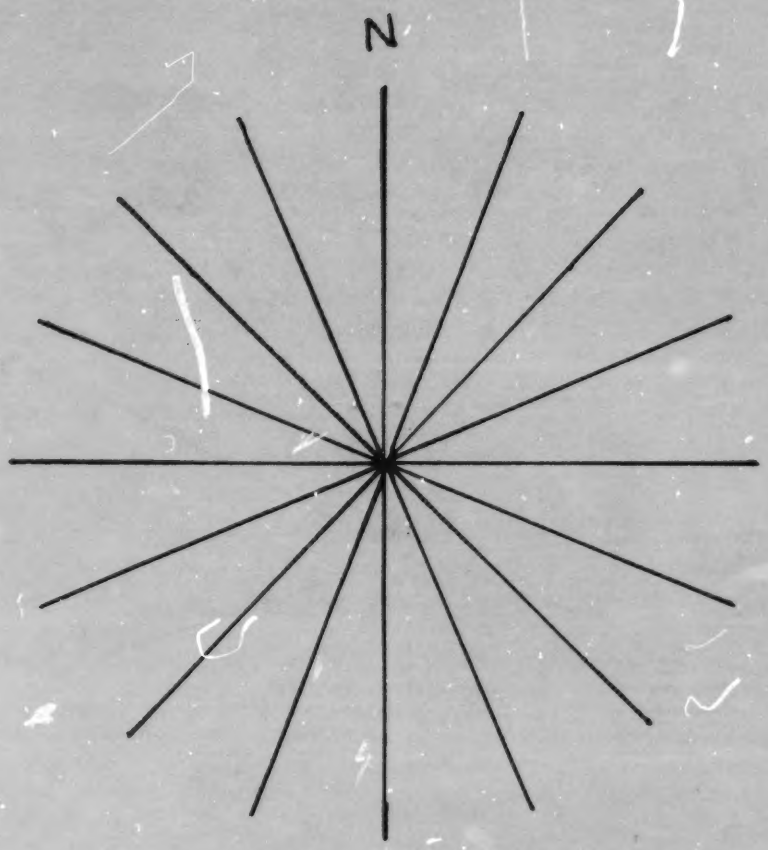
This lesson accomplished stated goals and objectives. The ease with which students perfected their compass skills and their positive experiences on the major field courses indicate the workability and success of the activity.

Two handbooks provided almost all the compass background material as well as the practice exercises and compass learning games.

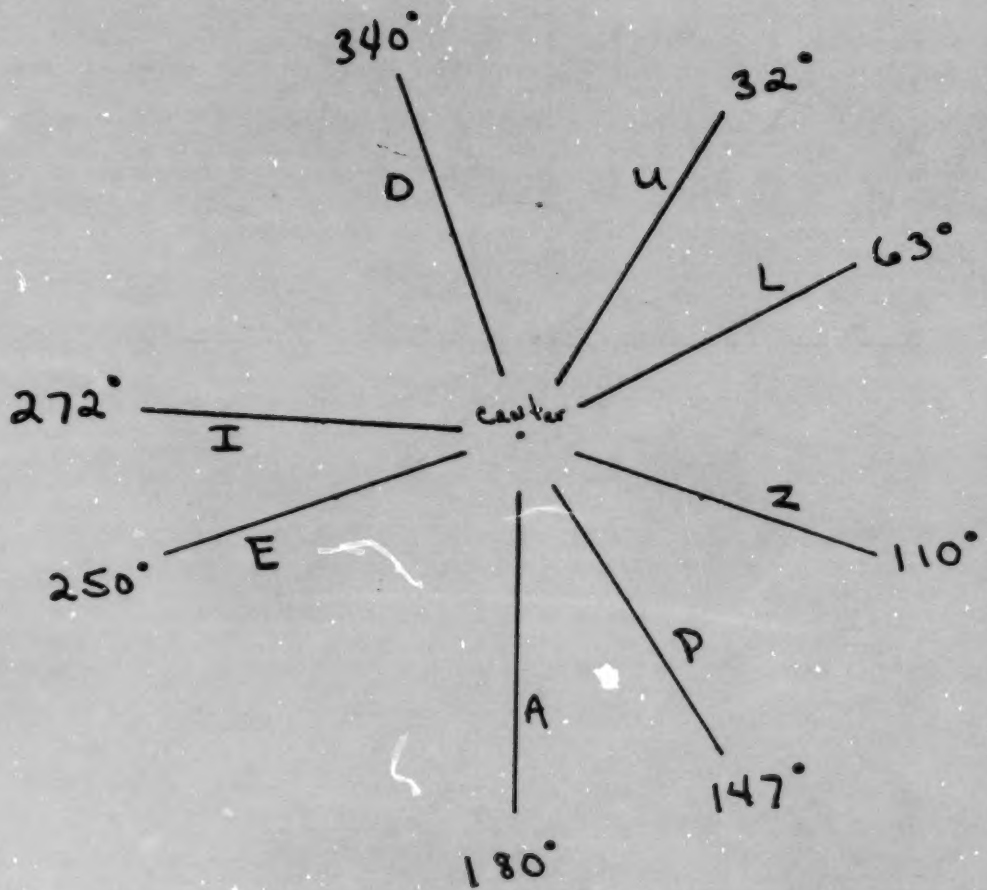
1. Be Expert with Map and Compass. Bjorn Kjellstrom, 1976. Charles Scribner's Sons: New York.

2. Tips and Tricks in Outdoor Education. Malcolm D. Swan, 1983. Interstate Printers and Publishers, Inc., Danville, Illinois.

COMPASS ROSE PRACTICE DIAGRAM



SCHOOLYARD COMPASS GAME



Preset Course

34

Schoolyard Compass Game

(Relay Instruction Card)

Sample

Start at stake marked		A
Proceed 305°	Stake letter	_____
29°		_____
100°		_____
162°		_____
221°		_____

Answer: Code word AEOUZP

Geometric Figures

Constructing a Square

1. Place first marker at feet.
2. Walk 10 paces at 90° and place the second marker.
3. Walk 10 paces at 180° and place the third marker.
4. Walk 10 paces at 270° and place the fourth marker.
5. Walk 10 paces at 360° and place the fifth marker.

Major Field Course

(Sample Teaching Station Card)

Field Station - "K"

Using the "pace" method, determine the length and width of the volleyball court.

What is the volleyball court's perimeter?

(Proceed to next station following listed azimuth.)

Major Field Course

(Sample Student Instruction Card)

Course #4

Start at station "K"
(near the volleyball court).

After answering the questions at field station "K" proceed, one by one, to the following stations by following the azimuths listed below.

84° to 312° to 249° to 208° to 193° to 163°

SOIL COLLECTION GUIDE AND ACTIVITIES

Carol Gatzke

OBJECTIVES

To collect and compare the phy .cal and biological properties of soils [illegible] three different habitats.

MATERIALS

For collection: soil probes, small shovels, baggies, thermometer marking pens, pH tester, light meter

For lab: microscopes, quart jars, soup cans

Books: A Guide to the Study of Soil Ecology, ed. William A. Andrews, Prentice-Hall.

Field Study Manual for Outdoor Learning. Margaret Milliken, Burgess Publishing company.

PROCEDURE

Go outside to three very different habitats and record physical and biological data at each site. Collect soil samples at each site to use in the lab for further study.

Activity 1 - Soil Collection

Students have an opportunity to collect data on the factors affecting soil composition, including data on ground cover, temperature, pH, light intensity, moisture, soil texture and color. (See attached soil collection guide and ground cover worksheet.)

This can be accomplished in a variety of ways. Students can work alone, in pairs, or in small groups. If your classes are large, it may be helpful to assign specific duties to group members.

After students have collected the data it is very important to discuss the results with them. Ask questions like, "Why is the soil in site 1 so much darker than it is at site 2?" or "How does the ground cover seem to affect soil texture?"

Activity 2 - Laboratory Analysis of Soil Samples

In this activity students will test the percolation rates of different soil types, study particle size and microscopically examine the soil for soil organisms. (See instruction sheets for soil particle size and percolation rate.) Microscopic examination of soil samples is done most effectively using a stereoscopic microscope (dissecting microscope). It is possible to view very small organisms using a compound microscope and a wet-mount slide.

SEPARATION OF SOIL ACCORDING TO PARTICLE SIZE

Soils tend to separate on the basis of particle size. The following exercise is a simple method for demonstrating this principle.

MATERIALS

large mayonnaise jar
sample of mixed soils from the same general area

PROCEDURE

a. Fill the jar approximately 2/3 full of water.

b. Pour in the soil until the jar is approximately half-full.

c. Agitate the jar vigorously for at least 30 seconds. Then let it stand until the soil settles.

DISCUSSION

Describe and account for the appearance of the settled soil. In particular, why do particles having the same density but different sizes settle at different rates? Describe and account for the appearance of the water above the soil. How does the principle illustrated in the exercise apply to the natural formation of soils?

PERCOLATION RATE: SPEED OF INFILTRATION INTO SOIL

This exercise is one which can be performed in the field.

MATERIALS

cans of the same size with both ends removed

PROCEDURE

A. Work each can into the ground about the same distance (about 2 cm.).

b. Pour a measured amount of water into each can.

c. Measure the time required for all the water to enter the soil. Record it for each can and average the results.

d. Repeat this procedure in several types of soil: in a lawn, on a dirt road, in a garden, in a deciduous woods, and so on.

3. If worm burrows are available, do one measurement with the mouth of a burrow in the center of the can.

DISCUSSION

Which soil types absorbed the water most rapidly? Why? State the advantages and disadvantages of fast infiltration of water into the soil.

Attempt this exercise using muddy water. Account for the difference in your results. How does this apply to percolation rates and erosion? How does the activity of worms help prevent flooding?

Activity 3 - Comparison of Soil Samples

Compare and contrast the different soil samples using the data collected, reference charts and other materials that show various degrees of soil fertility, best soil usage, and other soil characteristics. (See books listed under materials section.)

SOIL COLLECTION GUIDE - Activity 1 NAME_____
FIELD WORK DAY 1

Soil Collection Sites

lakeshore, woods,
field, bog

Materials

soil probe buckets marking pens
small shovel thermometer
baggies ruler

Plant Survey and Habitat (Gather the following information at each site.)

SITE_____

Vegetation types: name or describe plant species	Quantity	Possible effects on soil

SITE_____

Vegetation types: name or describe plant species	Quantity	Possible effects on soil

SITE_____

Vegetation types: name or describe plant species	Quantity	Possible effects on soil

GROUND COVER - Activity 1

The following three terms are used to describe organic matter at the top of the soil - litter, duff, humus. Examine each site and complete the following chart.

SITE_____

Term and Definition	Describe the feel and smell	List the identifiable parts of plants and animals found
LITTER (identifiable dead things on surface)		
DUFF (partially decomposed organic matter--compacted)		
HUMUS (almost completely decomposed non-identifiable organic matter)		

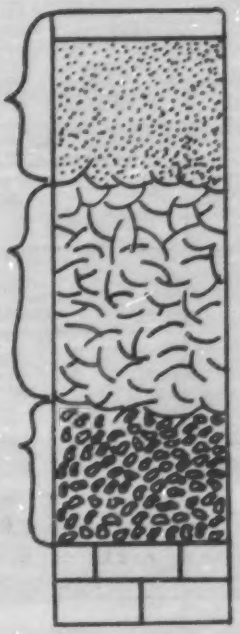
SITE_____

Term	Describe the feel and smell	List the identifiable parts of plants and animals found
LITTER		
DUFF		
HUMUS		

SITE_____

Term	Describe the feel and smell	List the identifiable parts of plants and animals found
LITTER		
DUFF		
HUMUS		

SOIL REFERENCE CHARTS



SOIL PROFILE

Duff	- Dead material on top of soil
Surface	- Dark brown colored - high organic matter, high biotic activity, abundand roots.
Subsurface	- Moderately dark - many roots, moderate biotic activity, moderate organic matter, commonly leached.
Subsoil	- Below plow depth - brown or reddish colored - more clay on the surface, fewer roots.
Lower subsoil	- More yellowish and less clay-fewer roots than subsoil, less aeration than above.
Parent material	- Unconsolidated - slightly weathered rocky or sandy mass from which soil develops, no biotic activity, few roots.
Bedrock	- Consolidated rock.

Effects of temperature on plant growth: Plants do not grow well when the soils are too cold or hot during the growing season. The following chart of temperatures applies to most of the temperature zone.

Soil Temperature	Growing Conditions
Less than 40°F	No growth, soil bacteria and fungi not very active
40°F to 65°F	Some growth
65°F to 70°F	Fastest growth
70°F to 85°F	Some growth
Above 85°F	No growth

Effects of color on soil.

Soil Surface Color (A Horizon	Amount of Organic Material	Erosion Factor	Aeration	Available Nitrogen	Fertility
Dark (dark grey, greyish) (brown to black)	Excellent	Low	Excellent	Excellent	Excellent
Moderately Dark (dark grey, dark brown) (to dark yellow-brown)	Good	Medium	Good	Good	Good
Light (Pale brown, yellow-) (brown to yellow)	Low	High	Low	Low	Low

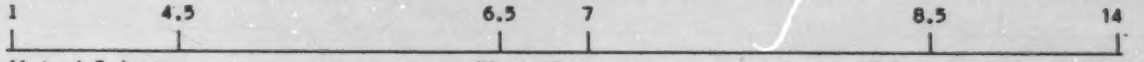
Effects of texture:

	Soil water holding capacity	Looseness
Sand	Poor	Good
Silt	Best	Good
Clay	High (low availability to plants)	Poor

Effects of structure:

Type	Pentration of water	Drainage	Aeration
columns	good	good vertical	good
blocky	good	moderate	moderate
granular	good	best	best
plazey (low rainfall soils)	moderate	moderate	moderate

Effects of pH on the soil: Plants need many food elements in order to grow well. These elements include nitrogen, phosphorus, potash and sulphur. The amount of pH affects how readily plants can get these elements.



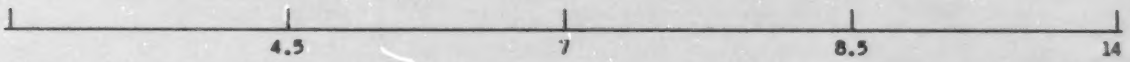
(1 to 4.5 is too acid for most plants)

(Most plants do best here)

(8.5 to 14 is too alkaline for most plants)

Example of plants in pH range:

pH 4.0 - 5.0: rhododendron, camellia, azalea, blueberry, fern
pH 5.0 - 6.0: pine, fir, holly, daphne, spruce, oak, birch, willow
pH 6.0 - 7.0: maple, mountain ash, pansy, aster, peach, carrot, lettuce
pH 7.0 - 8.0: beech, mock orange, asparagus



(Most Acid)

(Neutral)

(Most Akaline)

Some pH's of common items: Soap - pH-9;
Seawater - pH-8; pure water - pH-7; sour milk - pH-5;
Orange juice - pH-4; Lemon juice - pH-3.

Effects of soil depth on plant growth and water storage.

Deep (42" and over) - Excellent plant growth and water storage.
Moderately deep (20" - 42") - good plant growth and water storage.
Shallow (20" and under) - poor plant growth and water storage.

SOIL COLLECTION DATA SHEET

Physical Factors	Habitat		
	Woods	Field	Bog
pH			
Light			
Moisture			
Color			
Texture (sand, silt, clay)			
Structure			
Temperature:			
3 feet above soil			
Surface of soil			
2-3 inches in soil			

A STUDY OF PIGEON LAKE

Floyd R. Henschel

OBJECTIVE

The study of a fresh-water ecosystem is complex, but it can also be rewarding. To really understand the ecology of a lake and what makes it eutrophic or oligotrophic, students must have the opportunity to examine it firsthand. Observation is the best way to learn about any natural system and how people's intrusion can affect it. By performing a few tests during the alloted time, students can learn how to determine the overall condition of a lake and attempt to assess the quality of water found in the lake. The major areas of concentration are physical features of the lake; a chemical analysis of water samples taken from the lake; and taking random samples of "critters" found in the lake - the biological approach. Associated topics tied into the lake study are pH scale, acid rain, southern Wisconsin lakes, and trout stream restoration.

MATERIALS

Collecting physical data

graduated cylinder (500 mls)
thermometers (C-F scale)
Secchi disc

Collecting chemical data

D.O. Hach Test Kit
pH Hach Test Kit
hardness Hach Test Kit
iron Hach Test Kit

Collecting biological data

sieves
screens
nets
Ekman dredge
plastic buckets
baby food jars

PROCEDURES: PHYSICAL DATA

1. Record the time of day and weather conditions.

2. Record the air and water temperatures (water at 6-inch depth).

3. Examine water by filling a 500-ml graduated cylinder. Note color and odor of water sample. Discuss clarity.

4. Using the Secchi disc, have two students measure the turbidity of the lake from the swimming raft at the smaller beach area on Pigeon Lake. One student carefully lowers the disc while the other students record the exact depth when the disc disappears from view. To ensure reliable readings, have the students repeat the measurement so they agree on the exact depth.

5. Record all data and return all equipment to the lake study equipment box.

6. Students and instructor put on life preservers and return to the boat and to shore following the completion of the measurement.

PROCEDURES: CHEMICAL DATA

CHEMICAL ANALYSIS OF WATER - Using Hach Test Kits

Test #1 - Hardness ("hard" water)

Explanation - Hardness of water originally was defined in terms of its ability to precipitate (lather) soap. Calcium and magnesium ions are the principal causes of hardness in natural water, though other ions are capable of producing ther same effect (Fe, Al, Mn, and Zn).

Large amounts of hardness are undesirable for aesthetic and economic reasons and must be removed before water is suitable for use in the beverage, food, laundry, and paper industries.

Procedures - Titration Method (Hach Kit)

1. Fill plastic measuring tube with water and pour samples into the square glass bottle.

2. Take one plastic pillow (purple color) - violet (Uni-Ver), cut open, and pour contents into the water sample. Swirl, but do not spill. Liquid will turn pinkish-red.

3. Titrate, using tritant solution Hardness 3, drop by drop, until the liquid turns bluish-purple. Be sure to count the number of drops used, since each drop is equal to 1 grain.

4. Record answer in "grains" of hardness.

5. Wash square bottle thoroughly before doing the next test.

Test #2 - Iron

Explanation - Natural waters contain variable amounts of iron despite its universal distribution and abundance. Iron in ground waters normally is present in the ferrous (Fe+2) or soluble state, which is oxidized easily to ferric (Fe+3) or insoluble iron on exposure to air.

Iron in domestic water supply systems stains laundry and porcelain, causing more of a nuisance than a potential health hazard. Taste thresholds for iron in water are 0.1 ppm ferrous iron and 0.2 ppm ferric iron, giving a bitter or astringent taste. Water used in industrial processes must usually contain less than 0.2 ppm total iron. Domestic water supplies containing more than 0.3 ppm total iron should be rejected due to staining and taste considerations.

Procedures - FerroVer and TeVer Methods (Hach Kit)

1. Fill plastic cylinder with water and pour samples into the square bottle.

2. Take one plastic pillow from the plastic container labeled FerroVer (white) and pour contents into the water sample.

3. Shake vigorously, but do not spill the contents.

4. Match the color of the square bottle's liquid with the iron indicator cube and record the reading.

5. Wash all glassware thoroughly before putting the kit away.

Test #3 - pH

Explanation - The pH value of a water expresses its tendency to accept or donate hydrogen ions on a scale of 0 (very acidic) to 14 (very basic). Pure water at 25°C is neutral and has a defined pH value of 7.

Most natural waters range from pH 4 to a pH 9 and are often slightly basic due to the presence of carbonates and bicarbonates. A major deviation from the normal pH for a given water indicates the intrusion of strongly acidic or strongly basic industrial wastes.

Procedures - pH Colorimetric Method (Hach Kit)

1. Fill the two glass containers with water sample up to the white line marked on each cylinder. Place cylinders back in the black plastic holder.

2. To the cylinder on the right add 6 drops of the pH dye from the large plastic container (pH indicator solution).

3. Take the cylinder out of the black container and swirl until the water and dye are thoroughly mixed. Return to black container.

4. Take out the color disc (color comparator) and place inside the black container. Make sure the numbers on the disc are facing you. Close securely.

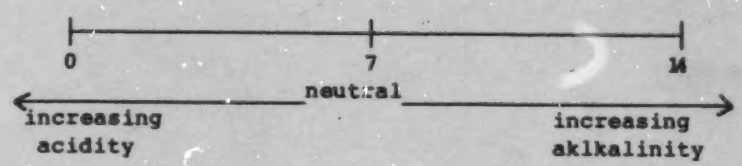
5. Hold up the black container to the sky so you can easily compare the color of the disc and the color of the cylinder with the pH dye in it. When the two colors match, record the number which is the pH reading.

6. Wash the two glass containers before putting the kit away. Store the color disc in the plastic wrapper as soon as you get the pH reading.

pH Scale

The pH scale is used to measure the number of hydronium ions in an acid or base solution. The pH scale ranges from 0 to 14. Seven is the neutral point. A pH above 7 indicates a base. A solution with a pH below 7 is an acid. pH can be measured with a meter, with paper, or by the colorimetric method.

pH Scale



pH examples -	auto battery acid	= 1.0	
	vinegar	= 2.7 - 2.8	
	"pure" rain	= 5.6 - 5.7	(acidic)
	distilled water	= 7.0	(neutral)
	baking soda	= 8.5	(basic)
	milk of magnesia	=10.5	
	ammonia	=12.0	

Test #4 - Dissolved Oxygen (Oxygen that is dissolved in water)

Explanation - The dissolved oxygen test is one of the most important analysis for determining the quality of natural waters. The effect of oxidation wastes on streams, the suitability of water for fish and other organisms, and the progress of self-purification can all be measured or estimated from the dissolved oxygen content.

Dissolved oxygen is essential for the survival of aquatic plant and animal life. Generally, 4-5 ppm dissolved oxygen content is a borderline concentration if considering an extended time period. For adequate game fish population, the dissolved oxygen content should be in the 8-15 ppm range (average - 9 ppm).

Dissolved oxygen concentration varies with water depth, temperature, clarity, sludge deposits, and flow rate; thus a single water sample is rarely representative of the overall condition of a body of water.

Procedures - Dissolved Oxygen - Azide Modification of Winkler Method (Hach Kit)

1. Open the large grey cannister (sampler).

2. Place round-bottom glass bottle (sample bottle) inside cannister. Clamp shut. Place rubber stopper in air tube (grey plastic tube).

3. Lower to desired depth and pull out rubber stopper. Hold cannister in position until the air bubbles stop rising. Raise cannister by chain.

4. Remove sample bottle from cannister with water sample.

5. Add pillows #1 and #2 to water sample and quickly put glass stopper in place. (Dissolved oxygen #1).

6. Shake vigorously for ten seconds and allow the precipitation to settle to the white line on the bottle. Be sure to grip bottle securely before you shake. (Dissolved oxygen #2).

7. Remove stopper and add pillow #3. Put stopper on bottle and shake once again. (Dissolved oxygen #3).

8. Fill the plastic cylinder (plastic measuring tube) taking prepared water sample from the bottle and pour sample into the square-bottom bottle (mixing bottle).

9. Now, drop by drop, add the PAO titrant until the liquid turns from yellow to clear. Each drop added represents 1 ppm of D.O. present in the water sample. Be sure to swirl the sample to mix after each drop of PAO titrant.

10. Replace top on PAO titrant as soon as you have determined the D.O. Wash all glassware thoroughly.

PROCEDURES: BIOLOGICAL DATA

1. Using the collecting equipment received from the instructor, students are to collect as many "critters" as they can find along the shoreline of the beach area. Then put the collected specimens in plastic buckets or baby food jars.

2. Students on the raft will use the Ekman dredge to take samples from the lake bottom and check the samples for "critters."

3. They should count all fish, turtles, frogs, and crayfish they see and catch, but must return these organisms to the lake as soon as they are done with observations and counting.

4. All students then return to the wet labs in the lecture hall to examine, under the microscopes, the specimens collected.

5. Students attempt to identify as many "critters" as they can in the allotted time, using the biological keys found in the lab. Encourage those who are confused to ask the instructor for help.

SUMMARY

1. Students at Science World '84 filled out the attached data collecting sheets from their lake study activities and the following data were collected concerning Pigeon Lake. All numbers are averages from the six different groups who did the collecting. No great differences were recorded except for the air temperatures (see attached).

2. In a follow-up study, the lake and bog water communities were compared and the students drew up a list of differences and similarities between the two environments. All tests completed in the lake study were mentioned, and trout stream restoration programs were talked about to conclude the follow-up study on different water environments found in Wisconsin. (See attached.)

3. Acid Rain Discussion

Acid rain is what is sounds like - rain that is a mixture of water and sulfuric and nitric acids. There are also acid snow, sleet, hail, and fog, all precipitating out of a vast chemical soup of pollutants in the atmosphere.

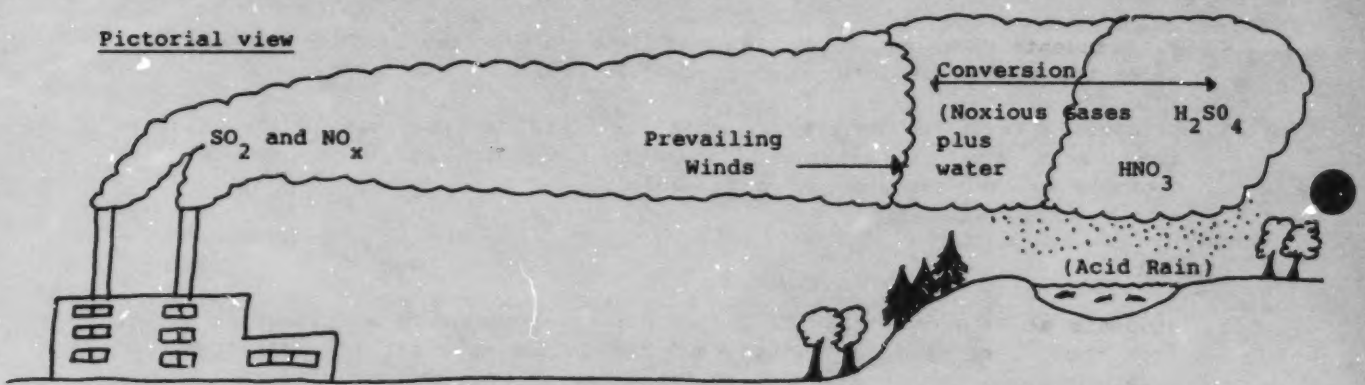
Acid rain forms when sulfur dioxide (SO_2) and nitrogen oxides (NO_x) are themselves oxidized to sulfates (SO_4) and nitrates (NO_3) in a complex process involving sunlight, heavy metals, ammonia, and smog. The sulfates and nitrates react with moisture in the air to become sulfuric (H_2SO_4) and nitric

(HNO_3) acids, and this acid material can ride the wind for hundreds of miles and several days, but inevitably it comes to earth, bringing a plague of environmental afflictions.

The damages of acid rain encompass everything from erosion of statues to destruction of whole aquatic ecosystems. It is most harmful where soils are thin or sandy with little calcium to buffer, or absorb, acids. Lakes and streams in these sensitive areas have been acidified to a point where fish and other organisms can't live there. The acids cause toxic metals, notably aluminum, to leach from soils into lakes; the aluminum compounds then become attached to fish gills and cause mucus to form, suffocating the fish. Acids also disrupt the reproductive systems of fish; they cause calcium to leach from bones, deforming small fish. In Minnesota, acid rain is threatening life in 1,500 of the state's 10,000 lakes. In Ontario, Canada, acid rain has killed the fish in 1,200 lakes, and the Canadian government estimates that 48,000 lakes are threatened.

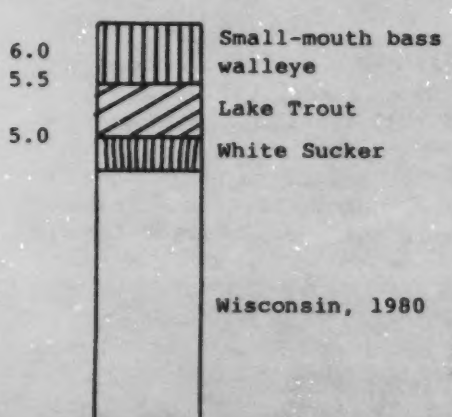
The primary cause of acid rain is air pollution from the combustion of coal and petroleum fuels. Each day electric utilities, factories, and cars together spew large amounts of sulfur dioxide and nitrogen oxides out of their stacks and pipes and into the atmosphere.

Pictorial view



Sources
Smelters
Auto Engines
Furnices of Electric Utilities

pH Range of Fish Reproduction Interferences



Wisconsin, 1980

According to recent EPA Congressional testimony, rain falling on the northeastern United States and southeastern Canada today has an average pH of 4.2.

Where does all the acidity come from? Scientists estimate that about 60 percent of the acidity of rainfall is due to sulfur dioxide in the atmosphere, while the remaining 40 percent is due to nitrogen oxides. In other words, acid rain is produced by people. Controlling pollution will control the acid, and the effort should begin immediately.

Solutions

1. The stopgap measure of adding lime to lakes may keep them alive until some long-term solution is found, but "liming" is an expensive business.
2. Lower damaging emissions by using low-sulfur fuels, mined in the West.
3. Use "scrubbers" in utility plants (installation of antipollution devices).
4. Walk, bike, use public transportation, or car pool to lower auto emissions.
5. Reduce the height of smokestacks.
6. Wash coal before it is burned.
7. Continue education and research programs.

4. Discuss sources and types of water pollution found in southern Wisconsin lakes demonstration eutrophication. Lake examples included in the discussion at Science World were Beaver Dam Lake, Belleville Lake, and Mendota and Monona Lakes in Madison.
   a. biodegradable wastes (aerobic-anaerobic bacteria)
   b. plant nutrients (nitrogen-phosphorous-potassium-algae bloom-eutrophication).
   c. sediments (runnoff-siltation).
   d. poisonous wastes (pesticides, mercury, lead, and PCP's).
   e. sewage treatment (raw sewage, leaky septic tanks, runoff from fertilized farms, and cattle feed lots)

5. Discuss the requirements (habitat) trout need to survive in a trout stream:
   a. cold water (13°C [55°F] necessary for reproduction; 13°C - 18°C [55°F - 65°F] can survive),
   b. sand-and-gravel-type stream bottom,
   c. clear, clean water,
   d. abundance of food (invertebrates),
   e. pH (7 to 9),
   f. cover or shelter from predators.

6. Discuss the three questions DNR authorities ask before they will begin a trout stream restoration program.
   a. Is the stream spring fed?
   b. Does the stream stay open for the entire winter?
   c. Will the stream support trout reproduction?

   If the answers to all questions are affirmative, the trout stream can be restored and eventually be available for public fishing.

7. Complete the follow-up session discussion by showing the film, "The Way of A Trout." Copies of this film are available from the DNR film library in Madison, (BAVI, 1327 University Avenue, Madison, WI 53706; (608) 262-1644), or from chapters of Trout Unlimited that have purchased the film.

SAMPLE OF DATA COLLECTING SHEET: (Student)

I. SPECIFIC MEASUREMENTS

A. Date _____

B. Time _____

C. Weather Conditions _____

D. Air temperature _____C _____F

E. Turbidity (Secchi disc) _____ feet _____meters

F. pH reading _____ (basic or acidic?) _____

G. Hardness reading _____ grains x 17.1 = _____ppm

H. Iron reading _____ppm

I. Dissolved oxygen rading _____ppm.

J. Water depth _____feet _____meters

K. Bottom description _____ odor?_____

L. Color _____

M. Odor _____

II. Collecting and Identifying Specimens

Description of where found	Sketch of organism	How many	Common name

BOG STUDY

Gary Loertscher

OBJECTIVES

1. To measure and study chemical, physical, and biological features of a northern Wisconsin bog.

2. To experience the aesthetic qualities of the unique bog environment.

3. To perform a comparative study of Pigeon Lake and the bog.

MATERIALS

Hach Water Testing Kit (pH, dissolved oxygen, hardness)
thermometer
Secchi disc
some type of "critter catching" device
four handouts:
a. "Bogs - Amazing Places"
b. "Bog Succession"
c. "Common Plants of Bog"
d. data sheet

PROCEDURE

1. Introduce by going through "Bogs - Amazing Places."

2. Point out succession as you enter bog.

3. Allow students to investigate, explore, and experience the bog. Because bogs are extremely fragile ecosystems, students should only use established trail or boardwalk. Have students try to find the plants pictured on the handout. Indicate that the pitcher plant, sundew, and bladderwort are insectivorous.

4. Show plants that students have not found after 10 minutes; also point out tamarack and black spruce.

5. Conduct tests (pH, hardness, dissolved oxygen), take physical measurements (air temperature, water temperature, water clarity, depth, and color), and collect critters.

6. Summarize all data collected.

7. Allow students to reach down into peat up to their elbows, grab a handful of material, and bring it up. Smell the bog material.

SUMMARY

Through the bog experience, challenge students with questions such as the following.

1. Why do bog plants have desert-like adaptations? (Plants have a very difficult time absorbing the cold water of bog.)
2. Why are there insectivorous plants in the bog?
3. Why is there a limited number of plant species growing in the bog?
4. Why does the tamarack, a coniferous tree, lose all its needles in the fall?
5. Why is the bog so acidic?
6. Why is the water blackish-brown?
7. Why was sphagnum moss once used as a sterile hospital dressing?
8. Why are there so few critters?
9. Why is the bog water cold?
10. Why aren't nutrients efficiently recycled in a bog?
11. Why does it get so cold in a bog at night?

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SPECIFIC MEASUREMENTS

A. Date and time _____

B. Air temperature _____

C. Water temperature

1. Surface _____

2. 10 inch depth _____

D. Lake transparency (Secchi disc measurement) _____

E. pH reading _____; (acidic or basic) _____

F. Dissolved oxygen reading _____ppm

G. Hardness reading _____grains; (hard or soft water) _____

H. Depth of water body _____feet

I. Type of bottom _____

J. Color of water _____

K. Odor _____

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Some Common Plants of
The Cedarburg Bog

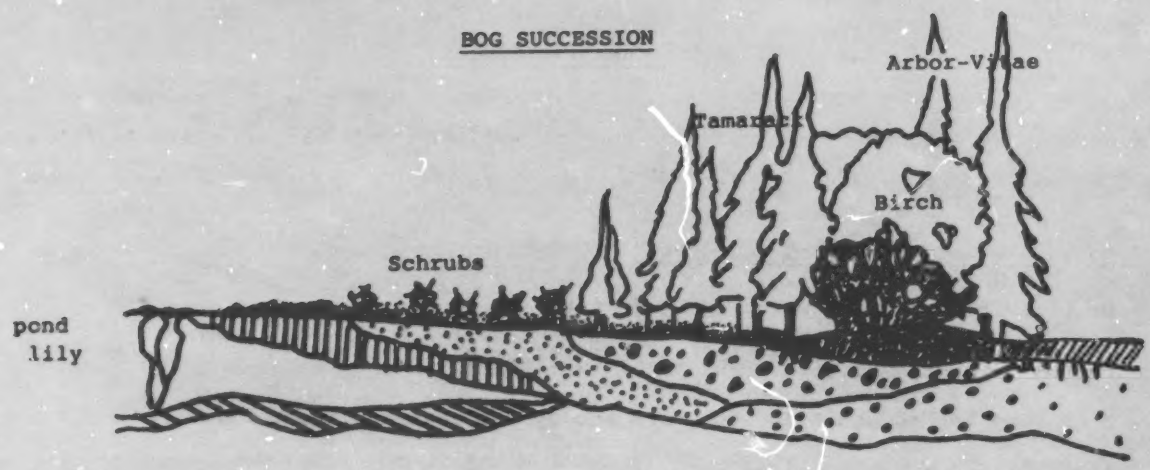
BOGS - AMAZING PLACES

Mind BOGling - A bog is a special type of wetland that has more similarities to a desert than a lake!

Some facts that won't "bog you down."

- Bogs can have flowing water; most do not.
- By definition, bogs are dominated by coniferous growth.
- Bogs were formed about 10,000 years ago by the last continental glacier.
- Bogs are "biological deserts."
- Bogs have eyes.
- Bogs suffer from "stress" (lack of oxygen, poor nutrient release, cold).
- Bog plants "depend upon each other for support" (roots intertwine, close proximity of growth).
- There are meat eaters in bogs; amazingly, most of them are plants.
- Bogs are deprived of nutrients. Nitrogen and iron are not released at all; potassium is released very slowly (Indians and settlers got a malleable iron out of bogs).
- Scientists are not sure what makes a lake go into bog succession rather than marsh succession.
- Frosts can occur on any night of the year in a bog.

BOG SUCCESSION



Water | False Bottom | Sedge Peat | Sphagnum Peat | Woody Peat

Altered Rock | Humus Layer | Live Sphagnum | Mesic Mosses

BOG VEGETATION

Submergent Vegetation:

Emergent Vegetation:
- Sedges

Low Shrubs or Heath:
- Leather Leaf
- Bog Rosemary
- Sundew
- Cranberry
- Sphagnum

High Schrubs:
- Bog Birch
- Poison Sumac
- Red Osier Dogwood
- Juniper
- Winterberry
- Black Chokeberry
- Dwarf Alder
- Velvet-Leaf Bilberry

Swamp or Bog Forest:
- Tamarack
- Cedar
- Paper Birch

String Bog (Flarks)
- Beak Rush
- Pitcher Plant
- Bog Bean
- Water Horsetail
- Bladderwort
- Phragmites

A COMPARISON OF DIFFERENT AQUATIC ECOSYSTEMS
(Followup to the Lake And Bog Study)

Gary Loertscher

OBJECTIVES

1. To summarize physical, chemical, and biological differences between the lake and bog.

2. To summarize physical, chemical, and biological similarities between the lake and bog.

3. To present information about other water ecosystems, in this case, a southern Wisconsin lake that is in advanced stages of eutrophication and a trout stream.

MATERIALS

Summary chart containing data collected at the lake and bog.
Posters, charts, and books pertaining to the topic.
16mm movie projector and the film, "The Way of a Trout."

PROCEDURE

1. Go over data collected at both sites.

2. Present background information about each of the tests conducted.

3. Emphasize interrelationships between the different test results at each site.

4. Try to discover why there were differences in the results found at the two sites.

5. Have students summarize how the lake and bog were different. Encourage them to look beyond the data collected. Then have students go through the same procedure with similarities between the two water bodies.

6. Present data collected from a eutrophic southern Wisconsin lake.

7. Present information about the requirements for a trout stream.

8. Show the film, "The Way of a Trout."

9. Followup with discussion of ecological concepts from the film and of "environmental ethics."

SUMMARY

A few of the key things the teachers at Science World noted about this session were that

- it emphasizes the interrelationships between different environmental factors such as temperature and dissolved oxygen;
- it allows students to analyze and question the data they have collected; and
- it shows that not all questions can be answered. Part of the beauty of science is that new questions that need to be answered always arise.

LAKE INVESTIGATION

Margie Dishno and Audrey Shomos

OBJECTIVES

- Define "limiting factors," "range of tolerance."
- Measure such limiting factors as temperature, visibility, dissolved oxygen, carbon dioxide, nitrates, pH, and phosphates through the use of various instruments.
- Predict what types of organisms might exist in the lake by looking at specific data concerning the ranges of tolerance for various aquatic organisms.
- Collect aquatic organisms.
- Illustrate and identify collected species through the use of microscopes and taxonomic keys.
- Compare findings with predictions.

MATERIALS

water chemistry kits
thermometers
Secchi discs
Ekman dredge
water sampler
dip nets
plankton nets
seine nets
bottles, jars
buckets
data sheets
compound microscopes
dissecting scopes
taxonomic keys

PROCEDURE

Introduce the terms "limiting factors" (biotic and abiotic) and "range of tolerance." Ask students to name some limiting factors that may be at work in an ecosystem such as a freshwater lake. List them on the board. Have students predict (brainstorm) what specific types of flora and fauna may be found in a lake. Announce to students that they will be able to test their predictions by measuring various physical and chemical limiting factors which exist in a lake. Explain procedures for the activity:

a. learning how to use the equipment,
b. measuring limiting factors and recording data,
c. discussion results and checking data tables,
d. collecting various organisms,
e. summarizing findings,
f. illustrating and identifying organisms.

Demonstrate equipment usage.

When you arrive at the study site, pass out data sheets. Split students into groups so that some are out on the lake taking H_2O samples, visibility measurements with Secchi discs, H_2O temperatures, and dredge samples. The remainder of the group should conduct water chemistry tests (O_2, CO_2, pH, PO_4, NO_3) from shoreline. Allow students to switch so that they can familiarize themselves with several tests or pieces of equipment.

At this point pull students together and average data; students should fill in data for all tests. Now have students check their data with the range of tolerance tables to find out what type of organisms could theoretically survive in this environment. Were their predictions correct?

Now allow students to collect aquatic criters, emphasizing that they would take turns with the equipment.

SUMMARY

Before the lab studies, group students together to further discuss data, this time elaborating on the meaning of each of the items measured. A good way of doing this is by comparing their results with those found in another aquatic environment, i.e., the bog, and pointing out the fact that although the same limiting factors are at work in both places - as they are anywhere else in nature - they are of different proportions than in the lake. Therefore, a whole different set of controlling circumstances result in a unique set of flora and fauna for each particular ecosystem.

Upon returning to the lab, give students their illustration/identification assignment (see objectives). Be certain to provide students with an adequate amount of time in the lab.

BOG STUDY

Margie Dishno and Audrey Shomos

OBJECTIVES

- To investigate and collect data on the limiting factors (physical and chemical) which influence a bog.
- To investigate plant and animal communities found in the bog.
- To compare the bog ecosystem with other aquatic ecosystems.

MATERIALS

LaMotte and Hach Chemical Test Kits (dissolved oxygen, carbon dioxide, phosphate, nitrate, pH)
Secchi disc
plankton nets
thermometers
dip nets
land lenses
Ekman dredge
binocular microscopes) petri dishes, microscope slides, and cover slips
compound microscopes)
sponge
three charts to insert in notebooks: (1) water analysis data; (2) tolerance levels; (3) drawings for notebook (sketches).
identification keys for algae, aquatic insects, plankton
Pond Life guides (Golden Guides)

PROCEDURE

Introduction

1. Discussion questions:
   a. What do you think a bog is?
   b. What kinds of things do you expect to find in a bog?
   (Do not tell them what they will find at this point; leave it open-ended.)

2. Key question: What determines the types of organisms that might be found in a bog?

   Answer: limiting factors. Guide students and give them clues until they come up with this term.

3. List some limiting factors on the board:

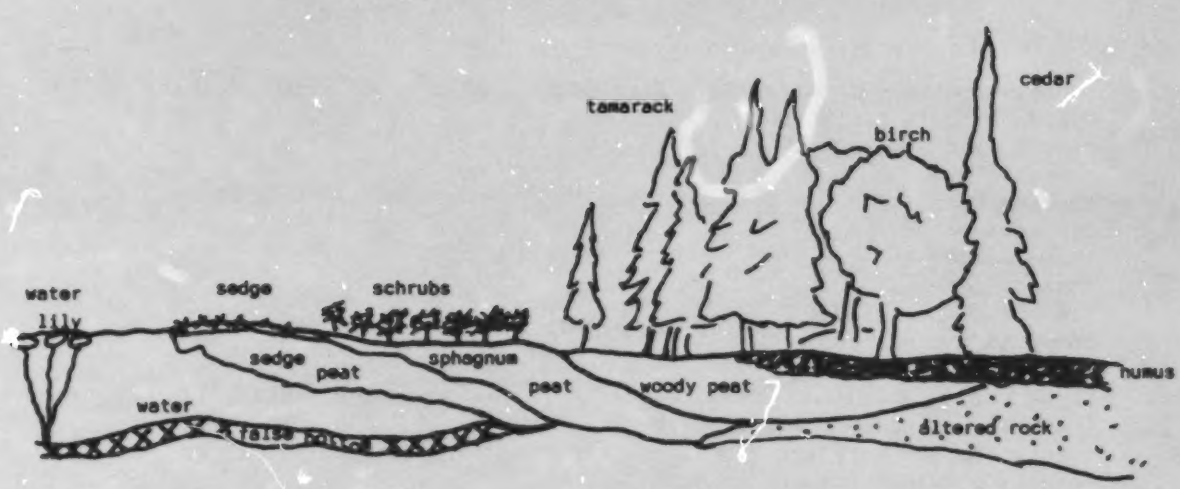
temperature	turbidity	oxygen
carbon dioxide	pH	phosphate
nitrate	others	

4. Main idea: The bog is a unique ecosystem, and the organisms found there are determined by its limiting factors.

5. Make a list of predictions. What specific organisms do students think they will find? Fill out first column on chart of tolerance levels.

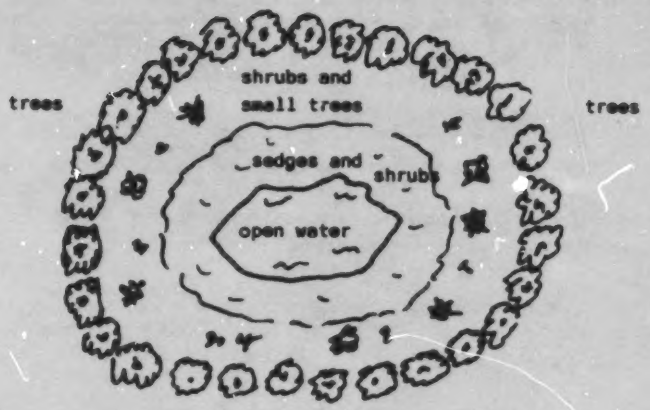
6. Background information: Present this to the students and ask them to take notes.

   Bogs have no inlets or outlets. The resulting water is still, stagnant, only replenished by rainfall and run-off.



A bog is constantly undergoing succession. The key plant in this process is sphagnum moss. Sphagnum is constantly growing and pushing out into open water, and it accumulates in layers over hundreds of years. The outer margins of the bog are becoming more stable, while the innermost margins of the sphagnum are very unstable, often floating over the water. The process of decomposition is very slow in a bog. The layers of sphagnum become peat as they decompose.

Depending on the stability of the ground and sphagnum, certain plant species grow at the various stages of succession. View from above:



7. Give students the following plant list. Tell them to list these in their notebooks, with hints to help them find each plant when they get to the bog.

Plant Name	Hint
Sphagnum	No hints
Black Spruce	coniferous tree
Tamarack	coniferous tree, soft needles
Grass Pink	orchid, 1-2 feet high, bright pink flower
Leatherleaf	shrub, oval leaves, leathery texture
Labrador tea	shrub, oval leaves, similar to leatherleaf, white fuzz on back side of leaves, odor
Sundew	tiny, low to ground, paddle-like leaves with tiny red spines, drop of sticky substance on the end of each spine
Pitcher plant	pitcher shape, collects water, tall, single flower
Cranberry	tiny vine, 6-8", several tiny leaflets, low to ground, single pink flower at end of stem or vine
Cottongrass	tuft on end

Teacher Demonstration

8. Demonstrate the use of the water testing equipment (Chemical test kits, Ekman dredge, plankton nets, Secchi disc, and thermometers).

9. Hand out data charts for students to tape into their notebooks; remind them to take note of the drawings to be made in the bog (five types of emergent plant life).

10. Hike to the bog; have students help you carry equipment.

11. Introduction: Sponge-squeezing contest.
Pick two student volunteers: one student has a saturated sponge and one student has a handful of sphagnum of approximately equal mass.

Contest: Count the number of squeezes until no drops of water can be squeezed out.

Result: Sphagnum will win. Emphasize that sphagnum is like a sponge, it can hold 16 to 18 times its own weight in water.

12. Divide the students into two groups.

Group 1: Conduct chemical tests using water samples from water in the sphagnum.
Do physical tests for turbidity and temperature.
Collect water samples and insects to take back to the lab, using nets and plankton nets.

Group 2: Go exploring in the bog itself.
Look for plants on the plant list and make sketches.
*Emphasize that this is a delicate ecosystem; tell students not to walk in the same paths as anyone else.

After ½ hour, have groups switch activities.

13. Return to classroom.

Summarize and wrap-up.
Review data and fill in charts. Discuss limiting factors. Organisms which live in the bog are unique; they do not live anywhere else. For example, you do not find cattails in a bog or sphagnum in a marsh.

Conclusions: Conditions in a bog are harsh: low dissolved oxygen, high pH, high CO_2, low levels of nutrients, cool temperatures.

14. Compare data and findings in the bog with the data collected in the lake study. Discuss the differences in limiting factors.

Wet-Lab Studies

15. Using compound and binocular microscopes, examine the water samples and insects from the bog. Have students draw sketches of and identify what they see. Use a variety of identification keys for algae, plankton, invertebrates, and other live forms, and the Pond Life books (Golden Guides).

Call students' attention to the list of minimum requirements for sketches:
two types of zooplankton,
two types of aquatic insects,
one type of algae.

ORGANISM	TOLERANCE LEVELS FOR LIFE, GROWTH AND REPRODUCTION			ESTIMATE WHETHER ORGANISM LIVES IN LAKE/BOG BASED ON MEASUREMENTS			
	pH	Dissolved O_2 (min.)	(°F) Temperature	Lake yes	Lake no	Bog yes	Bog no
Trout	7.0-9.0	7ppm	32-68				
Bass	6.5-8.5	3ppm	32-80				
White Sucker	6.0-9.0	3ppm	32-80				
Mayfly	7.0-9.0	7ppm	32-68				
Caddis Fly	7.0-9.0	7ppm	32-68				
Snails; clams	7.0-9.0	NA	NA				
Crappie	6.5-8.5	3ppm	32-80				
Bacteria	1.0-13.0	NA	NA				
Most Aquatic Plants	6.5-12.0	NA	55-80				

WATER ANALYSIS DATA

Water source_____

Physical Tests	Lake	Bog
Temperature (Indicate °F or °C)	_____	_____
Turbidity	_____	_____
Chemical Tests		
pH	_____	_____
Dissolved oxygen (O_2)	___ppm	___ppm
Carbon dioxide (CO_2)	___ppm	___ppm
Nitrate (NO_3)	___ppm	___ppm
Phosphate (PO_3)	___ppm	___ppm

Draw and label the following in your notebooks:

Lake

- 3 types of zooplankton
- 2 types of algae
- 3 types of emergent plant life
- 3 types of aquatic insects

Bog

- 2 types of zooplankton
- 5 types of emergent plant life
- 2 types of aquatic insects
- 1 type of algae

ALDO LEOPOLD DISCUSSION

Gary Loertscher

OBJECTIVES

To discuss, analyze, and reflect upon the writing and philosophy of Aldo Leopold.

MATERIALS

One handout - A collection of excerpts from A Sand County Almanac by Aldo Leopold. (You can develop your own according to the level of the student you are working with.)
Copies of the book, A Sand County Almanac.
Movie - "A Sand County Almanac" (Show this a day or two before the discussion.)

PROCEDURE

1. Conduct informal small-group discussions, preferably outdoors.

2. Introduce Leopold to the group; some key points are that
   - he lived in Wisconsin;
   - A Sand County Almanac, a collection of essays, was at first unknown, but became extremely popular in the 1970s and 80s.
   - Leopold probably has had more impact upon modern "environmental thought" than any other individual;
   - he was a world-renowned scientist; his writings combined the skills of a scientist with the charm of a poet;
   - he had a great mastery of the English language;
   - Leopold had something to say; he was prophetic.

3. Several approaches to the discussion can be taken, depending on the size of the group and time provided. The following procedure worked well at Science World. Allow students to work alone, with a partner, or with two other students. Given them a copy of the handout. Have each individual or group choose a quotation or two to discuss. Give students five minutes of preparation time. At the end of that prep time, each individual or group is responsible for leading a short discussion on the quotation selected. Encourage free interchange.

SUMMARY

This is a good way to get students thinking about the interrelationships within the natural world and of their own place in the natural scheme of things. For many people, A Sand County Almanac becomes a part of their lives, influencing both their thoughts and actions.

SLIDE PRESENTATION ON EAGLES

Floyd R. Henschel

OBJECTIVE

To have students define the term "endangered" and use the bald eagle as an example. Also, to cover the major species of eagles found throughout the world.

MATERIALS

"We Care About Eagles" available in slides or filmstrip plus cassette from:

The National Wildlife Federation
Department CEC
1412 Sixteenth Street, N.W.
Washington, D. C. 20036

PROCEDURES

Students appear to learn more from the slides if the instructor talks about each slide rather than playing the cassette. It gives them an opportunity to ask questions when they see each slide which they may forget when they see the outstanding slides at the end. An excellent booklet is mailed to you when you purchase the slides to help you master the slide information.

SUMMARY

The slides work extremely well with environmental science classes at any age level. The following eagles are included in the presentation:

bald eagle
golden eagle
Bateleur eagle
Phillippine eagle
harpy eagle

WILD EATS

Audrey Shomos

OBJECTIVES

To introduce students to common roadside plants.
To point out the basic structure of the plants as well as those parts which are edible.
To familiarize students with the necessary steps in the preparation of these food items.
To allow students to sample some wild edibles.

MATERIALS

wild edibles, 35 mm slides, pictures or samples
suitable area for collecting or observing
fresh and dried food samples
field guides

PROCEDURE

1. Present slides, pictures or samples of common wild edibles. Pass around samples while doing so.
2. Out-of-doors: Allow students to "pair up." Give each pair an area in which to search. Have a contest to see which group can recognize the largest of edible plants. If possible, bring students to an area where they can collect plants. Otherwise hike to a different area, such as a pond or marsh, and point out edible plant species common to that area.
3. If samples have been collected, they can be prepared for consumption. Otherwise a "tea party" is in order. Give the students an opportunity to sample some raw or prepared edibles and wild beverages which you have supplied.

SUMMARY

When you take your students out in the field, pass out field guides and share some recipes with the students that they might want to try at home. Or, ask students if their grandparents or other relatives used any of these plants as food.

Take time to point out to students the caution that must be exercised in accurately identifying plants for consumption. Also warn them about where and when to collect.

-Do not collect in areas that may have been affected by crop dusting.
-Do not collect in drainage ditches near major thoroughfares.
-Do not collect near fire hydrants or near sidewalks in urban areas (hint-hint)
-Never pick a plant unless there are several others of the same species in that area.
-When the slightest bit in doubt as to the identity of a plant, leave it alone; don't experiment.

THE LAKE SUPERIOR EXPERIENCE

D. M. Parr

(Many of these activities can be adapted for use in other areas.)

OBJECTIVES:

1. To involve the student in a holistic science study of Lake Superior.

2. To apply laboratory techniques in actual research settings.

MATERIALS:

The following handouts and equipment need to be provided:

Activity 1, Plankton Net Construction
- bent coat hanger frames (6" to 8" in diameter)
- (depending on age of students you may want to make these ahead of time)
- nylon stocking or pantyhose (net)
- baby food jars (collecting jar)
- 10 ft. of light rope (tow line)
- 2 ft. length of string - (attach bottle)
- 3 - ft. pieces of string tied together at one end (bridle)
- needle and thread
- darning needle
- scissors

Activity 2, Beach Succession Walk
- Script for path on Succession Walk which highlights vegetation and history
- Sand Dune Formation history sheet
- Data sheet for the walk
- Note: Vegetation will vary according to season.

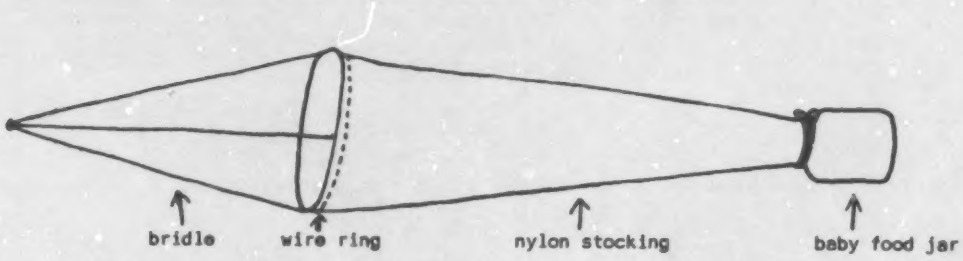
Activity 3, Boat Trip on Research Vessel L. L. Smith Jr.
- The crew and scientists do presentations and actively work with 18-20 students for three hours.
- See handouts.

PROCEDURE:

1. Follow directions on handouts.

2. Make arrangements for field station visit and use of boat. Direct correspondence to: Mary Balcer, Director, University of Wisconsin Vessel Program, C.L.S.E.S. - Barstow Hall, University of Wisconsin-Superior, Superior, WI 54380.

Activity 1: Plankton Net Construction

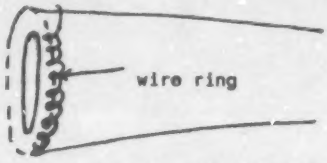


PROCEDURE:

Explain to the students what a plankton net is used for and briefly describe what they will be doing. It may be helpful to set out the materials on the student's desk or table beforehand to save time and minimize confusion. Depending on the age of your students you may want to move step by step through the instructions waiting till every student is ready before continuing. It's a good idea to give the following instructions to the students orally and in written form.

Step 1 - Insert the wire circle inside of the stocking so that there is about a one inch "collar" extending over the ring.

Step 2 - Sew the stocking to the wire circle using an overhand stitch. Make sure that the stocking extends over the wire circle equally as you continue to stitch.

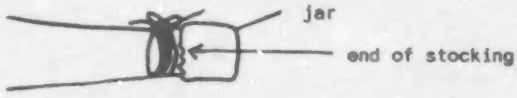


Make sure to leave about a four inch length of thread when you finish to tie a knot.

Step 3 - Return needle to teacher so it is not misplaced.

Step 4 - Cut off the stocking to 12 to 18 inches below the wire circle and throw away the "foot" section.

Step 5 - Take a piece of string and use it to attach the baby food jar to the end of the nylon stocking. Place the jar inside of the stocking so that only about half of the jar extends outside of the stocking.



Wrap the string around the neck of the jar several times and tie the string tightly.

Step 6 - Hold the net in one hand and gently tug on the bottle to test how well it is attached.

Step 7 - Take the three pieces of string that are tied together and thread on end of one piece of string through the large needle. Pull the needle through the stocking just under the wire circle. Remove the needle and tie the string around the wire circle. Repeat the procedure with the other two strings. Make sure to space the strings equally. Also be sure to keep the string of equal length so the wire circle hangs evenly when you hold the knotted end of the strings.

Step 8 - Pull gently on the bridle to check knots, retie if necessary.

Step 9 - Attach rope to the knotted end of the bridle.

Step 10- Your net is finished. Write your name on a piece of tape and place it on the jar. Clean up all your scraps and put the scissors and needle back where it belongs.

COLLECTING PLANKTON

Have students carry nets so jars won't hit anything. You may want to demonstrate proper carrying technique.
Walk students out to breakwall in single file, about five feet apart.
NO pushing or shoving should be allowed. Water is 30 feet deep and cold.
Walk until all students are past any people fishing.
Have each student wrap end of rope around hand and then lower net into water.
Students may have to "bounce" nets to get water into the jars.
Students should not throw nets away from wall and then pull them in. Jars will come off.
They must not hit jars on breakwall!
Tell them to walk slowly along the wall, pulling their nets. Nets must stay in the water.
Walk for about five minutes, then have students pull up nets and check catches.
If they wish, let them pull nets along as they walk back down the wall.
They should pull nets out before reaching any people fishing.
Have students walk back to picnic tables, carrying jars in hand.
Each can then open net, pulling jar up through net mouth, and pour plankton into another jar.
Nets can be left outside on tables.
Students should bring plankton inside to examine.

EXAMINING PLANKTON

Warn students that microscopes are expensive and should be handled with care. Go through all instructions before letting students touch scopes. Have students choose partners (two students per scope) and form a line. Assign each group to a microscope.

Instructions for Students

Pour a small amount of water/plankton into your petri dish; don't fill it more than half full.
Put petri dish on microscope. Turn on light (button on back of scope base).
Use the side control to focus, the top control to increase magnification.
Don't rub lenses with paper towels or anything else. Ask me to clean them if necessary.
Look at your sample under the microscope. Draw sketches of the animals you see.
Compare your sketches with pictures of plankton available in the lab. Can you identify the creatures in your plankton sample? How many of each kind did you catch?
When you have looked at everything in the dish, dump the liquid into the sink.
Pour more of your water sample into the dish and look at it. Keep going until you have looked at your entire sample. Who can find the largest number of different animals? Who has the largest animal? The most animals?
When you find something different, share it with the rest of the class.

If you have a lot of time left after students are done, have them sample water in a different area and bring it back to the lab to look at.
Save five minutes for cleanup. Have students
wipe up all water from scopes, counters, floor, etc.;
turn off microscope lights;
wash out petri dishes, slides, coverslips, etc.;
throw away garbage;
put jars for samples back on picnic table; and
set up net materials for next group.
Make sure NO ONE leaves until everything is cleaned up!

PLANKTON WORKSHEET

1. Sketch two to five phytoplankton (phyto means plant) that you see in your sample. Identify the plants you drew. Remember to use the pictures of the algae. Use the space below to draw your plants.

2. Draw three to five zoqplankton (zoo means animal) that you collected. If available, use an idenification key to identify your critters and label your drawings in the space below.

3. Which of your phytoplankton would be most easily eaten by zooplankton? Why?

4. Which zooplankton would be most difficult for a young fish to eat? Why?

Activity 2: Beach Walk (about 20 minutes)

Have students walk down to the lake to the right of the outer breakwall. Give them time to look at the water, jump waves, skip stones, etc. Don't let them walk out to the lighthouse because of the danger of someone accidently falling off. After they have had some fun, gather the group together.

Give the students the sheet on sand dune formation.

Discuss: How did this beach form?

Years ago, this area was covered by glaciers. As the ice melted, the water level rose; the water level was once 600 feet higher than it is now - up to Skyline Drive in Duluth. Gradually, as the water began to drain out of the far south end of the lake, the water level fell. Waves eroded the north and south shores of the lake, and currents carried sand-sized particles to its western tip. These particles piled up and built sand bars. As the lake level dropped, the beaches got wider. About 4,000 years ago, Minnesota and Wisconsin points emerged. Each point is getting bigger as more sand piles up there. We are standing on a fairly newly formed beach.

Question: Does anything live in this open area? What? Why?

There isn't much life here. The area is often covered by waves during storms and by ice in winter. Both tend to pull plants out by their roots. There is not much food for plants here either.

There may be a few insects in the rows of driftwood and debris that wash in after storms. Look at the rows of driftwood/debris. What is here? Where did this stuff come from?

How do seeds get to new areas and become established?
Wind, waves, and animals transport seeds from other areas.

What do plants need to grow?
Sunlight, water, nutrients.

Where do plants get these things?

Move inshore to the beginning of the grass zone.

Question: Why can grasses live here?

They are far enough back so waves or ice won't uproot them.

Question: Why aren't there more plants here?

It's a poor environment for plants, which need sun, water, and nutrients to grow. Sand is dry on top and wet further down (dig down). Plants must have deep roots to get to water. There are very few nutrients here - just pure sand. Grasses and beach peas can make some of their own nutrients. They also have deep roots, and can reach water. They keep growing upward to avoid being buried by the sand. Therefore, grasses and beach peas can survive; other plants are too delicate to live here.

Have students dig to see how deep the roots of grasses or beach peas grow. Be sure to fill in holes later. Ask them to try not to trample or destroy too many plants.

Start walking toward pine forest. Stop occasionally and gather groups together. Explain that this area is protected from wind and wave action. As grasses die, they decompose and add organic matter to the soil. More delicate species can then become established. This zone is still fairly sandy, though. To grow here, plants still need deep roots, or they must be able to withstand drying.

Have students point out the different plants they see, "Each time you see something, ask what it is." Keep track of how many different plants live in each area. Record signs of animal life.

Plants to look for between the beach and the woods

Wormwood. This plant lives for two years and has a very thick, long root. It lives in poor soil and disturbed areas. Indians dried parts of the plant and smoked them, but this must be done carefully. Wormwood is poisonous if used incorrectly.

Horsetails, or Scouring Rush. These grow in clusters; roots are attached. They are related to primitive trees and have silica in the stems for support. The stems are hollow, so they can stand to be dried out.

Strawberries. Strawberry seeds are brought here by birds, who also bring raspberry, blueberry, bearberry, and chokecherry seeds. Strawberries grow in open areas with a lot of sun.

Clumps of poplar, or Balm of Gilead. These began with one parent tree that grew from a seed washed in by the lake. When the parent tree died, young ones sprang up from the roots. The young trees are clones; they all have the same genetic makeup, and should all lose their leaves at the same time.

False Solomon's Seal. This is an early blooming spring plant. It likes sheltered areas.

Evening Primrose. This plant lives for two years. The first year, it has a rosette of leaves; the second year it grows a long stalk and has yellow flowers.

British Soldiers. This is a lichen, that is, a combination of fungus and an algae. Fungi, like mushrooms, can't make their own food, don't have chlorophyll, and live on dead trees, etc. Algae can make their own food, but need moist places to live.

As you enter the pine forest, point out that the trees are all the same size. Many were planted 40 to 50 years ago. Look for signs of rabbits and chipmunks here (rabbit droppings, chewed pine cones). Look at the soil and notice when it gets darker.

Plants to be seen in this area

Wild roses. These will have red rosehips from last year, full of seeds.

False heather. This heather fills in open, trampled areas. It is very woody, and withstands drying well.

Bearberry. Grows in large clumps and looks like blueberry. But bearberry has large seeds, red berries. Bears like them. There are, by the way, no bears on this end of the point.

Dwarf juniper. These low-spreading shrubs don't get very tall. They have bluish-green berries that used to make gin. The shrubs grow very slowly; some are 500 years old.

Poison ivy. It now has just stems and white berries, but will get three leaves soon. Poison ivy gets taller and has wider leaves in the shade. Why?

Reindeer moss. This is another lichen; it lives in cold, dry areas.

Real moss. Mosses form very soft mats and like moist, shady areas. Some can withstand dry conditions; these form mats that are not as large or as soft.

Club moss/Princess pine. This type of moss likes damp, very rich soil and shaded areas.

Earth star fungi. These live near pine trees in dry areas. Tell students to be careful not to get spores in their eyes.

Fungus mats. Students will find these dark clumps living on dead fallen trees.

Red pines. They have two long needles per cluster and red, shaggy bark.

White pines. These have five shorter needles per cluster and darker bark.

Birch trees. Birches grow only in open areas; they don't like to be shaded by pines. Pines were here first. Ask students how the clearing where the birches are now may have come to be. There could have been a fire . . ., but there are no blackened stumps in the area. Someone probably cut down some pines; there was a village on the point at one time.

Fern fiddleheads. Fiddleheads like shaded, moist areas and are edible when very small. As they grow, they take chemicals from the soil, which concentrate in the stem and leaves and give them a bitter taste. As these ferns get older, they can be poisonous.

Bunchberry has bright red berries in summer.

False lily of the valley has small white flowers.

Starflower and Twinberry may also be growing here.

There will be many other plants which you may or may not know the names of. Just keep track of how many different plants live here. The soil is very good because of all the plants that have died and decayed over the years.

When you hit the road, walk slowly toward the field station; watch the time so that you arrive when the next class is due to start.

Explain that land near Allouez Bay is made from dredge soils. The harbor was dredged to make it deep enough for boats, and the sediment was used to build up the land. If you have time, walk down to the beach on the Allouez side.

As you walk along the road, you'll see

Red Osier Dogwood. "You can always tell a dogwood by its bark."

Mullein. This plant has very soft, velvety leaves that were once used for the insoles of shoes.

Dandelions. These denote a disturbed area, people's influence.

By this time, most of the group will be spreading out. Let them talk to each other as long as they don't get too loud or destructive. Try to get everyone to return at the same time.

BEACH WALK DATA SHEET

During your walk, try to find each of these plants. Ask your teacher for help if you need it. How many of them do you know now, before you begin the walk?

	On beach	Between beach & woods	In woods	Along road
Beach grass				
Beach pea				
Wormwood				
Horsetails				
Strawberries				
Popular trees				
False Solomon's Seal				
Evening Primrose				
British Soldier				
Wild roses				
False heather				
Bearberry				
Dwarf juniper				
Poison ivy				
Reindeer moss				
Moss				
Club moss/Princess pine				
Earth star fungi				
Fungus mat				
Red pine				
White pine				
Birch				
Fern fiddleheads				
Bunchberry				
False lily of the valley				
Dogwood				
Mullein				
Raspberry				
Chokecherry				
Juneberry				
Balsam poplar				
Alder				
Yarrow				
Sheep sorrel				

SAND DUNE FORMATION

Wind and wave action are responsible for the extensive erosion of western Lake Superior's south shore. The prevailing north and northeast winds and currents carry the sand-sized particles to the western end of the lake, where they are deposited along Minnesota and Wisconsin points. During low water, the sand dries out and is transported landward by the wind until it is deposited against an obstacle such as driftwood or a growing plant.

Drought-resistant grasses that use rhizomes to spread rapidly and can grow upward to prevent burial in the blowing sand are usually the first species to grow on a beach. Wormwood, beach peas, evening primroses, and goldenrod then become established. These plants can grow on the few nutrients in poor soil and have extensive root systems that reach down several inches to the layers of moist sand below. Such plants help stabilize the dunes and prevent sand from blowing further inland.

When the "pioneer plants" die, they decompose and add organic matter to the sand. Over the years the soil becomes nutritionally enriched in this way and capable of retaining more moisture from rain and snow. The enriched soil can then support the growth of plants such as wild roses, false heather, juneberries, and birch, poplar, and white pine trees. Once the trees become established they provide shade for more delicate plants such as lilies, mosses, and bunchberries.

The sand bars of Minnesota and Wisconsin points offer excellent examples of all stages of dune formation and stabilization. These sand bars began forming approximately 4,000 years ago.

Barren sand dunes and pioneer vegetation can be observed near the Lake Superior shoreline, which is continually increasing. As you move inland, you will encounter older sections of the beach that are now stabilized by resistant plant species. The pine forests located near the centers of the points are in the oldest and most stable areas.

Activity 3: Field Trip Aboard University's Research Vessel

We are now going to explore the wonders of Lake Superior aboard the 63-foot-long research vessel L.L. Smith Jr. We will collect and examine many of the plants and animals live in the lake.

While we are busy getting the boat away from the dock and cruising out to our first sampling site, take a few minutes to read the next section on Aquatic Food Chains.

We will take groups of five through the pilot house to show you the latest navigation equipment. PLEASE BE QUIET WHEN IN THE PILOT HOUSE AND DO WHAT THE CAPTAIN TELLS YOU. WE DO NOT WANT TO HAVE ANY ACCIDENTS. THANK YOU!!

AQUATIC FOOD CHAINS

Any ecosystem, terrestrial or aquatic, must rely on "primary producers" or plants, to support all the higher-level consumers. In an ecosystem, the primary producers are considered the lowest "trophic level." ("Trophic" means "Of or pertaining to nutrition.") Organisms that feed on plants are called "primary consumers." Those feeding on primary consumers are secondary consumers, and so on, until the top-order predator in the food chain is reached.

The efficiency of conversion from one trophic level to another is often estimated to be about 10 percent. In other words, it takes about 100 pounds of plant material to produce 10 pounds of primary consumer, which are in turn eaten to produce one pound of a secondary consumer such as smelt, in an aquatic system. If the smelt is then eaten by a large trout, it will have taken 100 pounds of plant material to produce one tenth of a pound of trout! Obviously, the primary producers must constitute by far the largest biomass of any group in the ecosystem, and factors affecting them will be felt throughout the system.

The plants in aquatic systems may come from a variety of sources. In streams, the main source of plant material is the fall of leaves, twigs, and so on, which are produced on land. In lakes, almost all plants are produced entirely within the lake system itself. The rooted aquatic plants, called "macrophytes," are the most familiar. Included among them are emergent plants like cattails, wild rice, reeds, or arrowhead, and submerged plants like pondweed and elodea. The rooted aquatic plants play a major role in most aquatic environments, but are practically nonexistent in large, cold lakes like Lake Superior.

The second major group of primary producers is the phytoplankton component of the plankton found in most aquatic systems. Plankton includes phytoplankton (plants) and zooplankton (animals) that range from microscopic size to one centimeter long. All are free-swimming or free-floating in the "water column" - the water between the surface and the bottom of any large body of water.

Phytoplankton includes small single-celled or filamentous algae. Most familiar to many people are the floating algae, commonly called pond "scum." Most types of phytoplankton do not float on the surface, however, but live in the water column. This group is usually the most important to an ecosystem because it maintains oxygen levels in the water and provides a food base for all of the higher orders of animals. Like all plants, phytoplankton is very responsive to light, temperature, and nutrients and its abundance and distribution in the water column are largely dependent on these factors.

The remainder of the plankton in aquatic systems are zooplankton (animals). These small animals range from 40 microns to 18mm in size and are a major food for the young of fish such as the walleye, yellow perch, northern pike, and many others. They are also the primary diet of larger fish which filter the water for food, like lake herring and pink salmon. Many zooplankton feed on phytoplankton or microorganisms. Some are predaceous and feed on other zooplankton.

Zooplankton migrate through the water column daily. They tend to stay deep in the water during the day and come up much closer to the surface at night. These tiny creatures have been clocked actively swimming to the surface at a rate of 10 miles per hour! Their daily migration pattern has evolved due to various factors related, perhaps, to the needs to avoid plankton-eating fish by hiding in deep water during the day and to feed where phytoplankton are most abundant - near the surface - at night.

The organisms that live in the bottom sediments of a body of water are known as benthic organisms. A variety of types of organisms are found there, but the most common are the insects; the oligochaetes, which are related to the earthworms; a few crustaceans such as scuds and sowbugs; some nematodes; and clams. These organisms are the primary food for a number of major game and commercial fish species like whitefish, young trout, and salmon, and also feed small fish that serve as food for the larger fish.

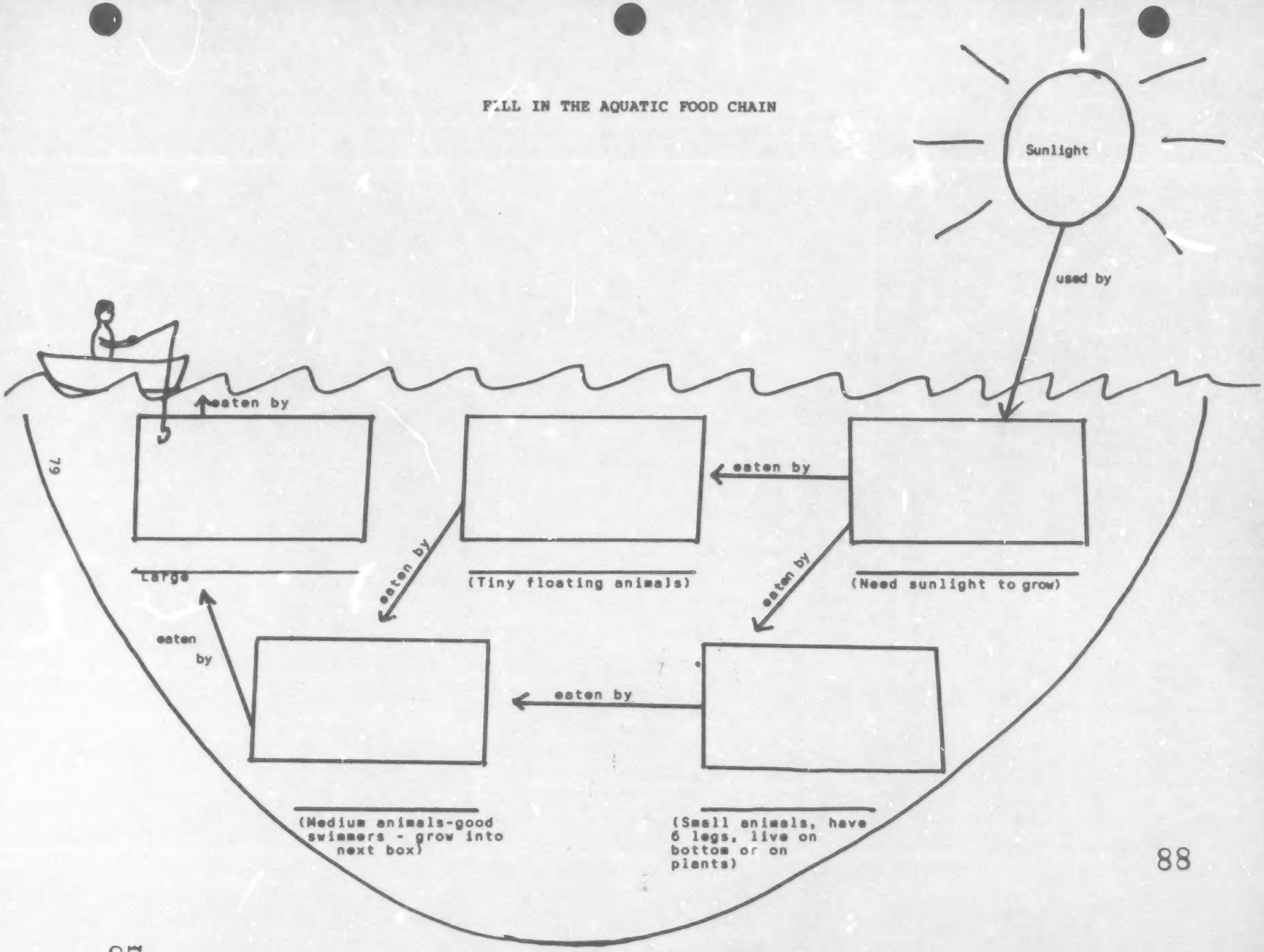
Benthic organisms can be quite numerous in aquatic systems, though most people are only aware of them where there is a large hatch of some of the insects that leave the water after they become adults, like mosquitoes. Studies of streams tributary to Lake Superior have found as many as 3,200 individual organisms in one square foot of stream bottom! Densities are generally lower in lakes, but it is not uncommon to find 200 to 300 individuals per square foot.

Benthic organisms in aquatic systems are often used as indicators of pollution. Some of them can adapt to very low oxygen levels, or to other types of pollutants which put some stress on a system. A "healthy" system, with few stress factors, generally has many different species of benthic organisms, but few individuals of each species. A more polluted system may actually have a higher total number of individuals, but many fewer species. These "pollution tolerant" species, although abundant, will not be useful as food for fish and other organisms.

The aquatic organisms best known to almost everyone are fish. They are of relatively minor importance if thought of solely in terms of their contribution to the biomass and to the total flow of energy through aquatic ecosystems. However, they are the group with by far the greatest economic importance, and management of aquatic ecosystems is often geared toward maximizing production of the more desirable fish species.

Fish are found in a variety of aquatic habitats. They may swim freely in the water column (pelagic) or stay near the bottom (benthic). They may eat plankton, plants, insects, or fish. They may prefer weedy, rocky, or even sandy areas. These food and habitat preferences vary, of course, with the species of fish, but can also change with the physical and chemical conditions of the water, between night and day, and as fish grow from the fry though the adult stages.

FILL IN THE AQUATIC FOOD CHAIN



BIOLOGICAL SAMPLES

1. What kind of sediment is located on the lake bottom here?_____

_____

2. What kinds of animals live on the bottom?

_____ _____

_____ _____

_____ _____

3. What kind of fish did we catch?

_____ _____

_____ _____

_____ _____

4. Do smelt have teeth?_____

What do they eat?_____

Do they chew their food?_____

How do they breathe?_____

5. Are there a lot of plankton at this sampling site?_____

OXYGEN - THE GAS OF LIFE
EXPERIMENTAL DETERMINATION OF OXYGEN IN WATER

General Considerations

The amount of oxygen gas (O_2) dissolved in natural waters is probably the most important determinant of water quality. Dissolved oxygen gas is essential to the following processes.

1. Respiration and Decomposition

   Animals take in oxygen and eliminate carbon dioxide when they breathe (respiration). Oxygen is also consumed in the process of decomposition. When aquatic plants and animals die, bacteria break down plant and animal material into simpler products like carbon dioxide. Bacteria need oxygen to do this.

   When there is not enough oxygen in the water, most forms of aquatic life cannot exist. After they die, the lack of oxygen in the water will also mean they'll be converted to toxic substances like methane gas ("swamp gas"), hydrogen sulfide gas (smells like rotten eggs), and phospine gas (also has a strong odor).

   When certain pollutants, for example, organic wastes, are added to water, bacteria begin breaking them down and consuming oxygen in the process. If the amount of waste is large enough, bacteria may use up all the oxygen gas in the water, or the oxygen level may get so low that fish and other aquatic life forms can't survive. Many fish kills have resulted from the dumping of organic wastes into lakes and rivers.

2. Photosynthesis and Air Exchange

   Photosynthesis is one process that adds oxygen to water (and air). Green plants, which contain chlorophyll, take in carbon dioxide and water and, in a series of chemical reactions, convert them to O_2 gas and sugars.

   Some oxygen from the air also dissolves in water. This process is called air exchange.

   Photosynthesis and air exchange are the only two processes that put oxygen into water. But there are many processes that take oxygen out of water, as section 1, above, indicates.

3. Solubility of Oxygen in Water

   Oxygen gas is not very soluble in water. Aquatic plant and animal life have evolved so they can survive on the levels of oxygen found in water, which are much lower than the oxygen levels found in air.

   Varying conditions, like temperature, affect the amount of oxygen gas that can be dissolved in water. O_2 is more soluble in cold water than in warm water.

When water has dissolved as much oxygen gas as it can, it is said to be "saturated" with oxygen. A cold stream will hold much more oxygen at saturation than a warm pool. Because trout need much more oxygen than catfish, trout can live only in cold water systems where oxygen levels are highest. Catfish, with lower oxygen requirements, can live in cold or warm water systems.

Much aquatic life needs near-saturation levels of oxygen in water to survive. Oxygen saturation levels for water at different temperatures are given below.

Temperature in degrees Centigrade	ppm of oxygen (0_2) at saturation
0	14
10	11
20	9
30	7.5

The saturation values are listed as "ppm," or parts of oxygen per million parts of water. For example, at 0° Centigrade, one million pounds of oxygen-saturated water (123,000 gallons) will hold 14 pounds of oxygen.

Sufficient green plant life - aquatic weeds, algae, and phytoplankton - is also necessary if a lake is to have a good supply of oxygen. But if excessive amounts of plant life are present, as they are in swampy areas and lakes with high algae growth, the decay of these plants, as they die, may reduce oxygen to very low levels.

Light penetration also affects the oxygen content of water, because sunlight is necessary for photosynthesis to occur. If water is clear, sunlight can penetrate to great depths and make 0_2 production possible deep in the water. When sunlight can't penetrate to the bottom of a lake, for example, the lake may be oxygen deficient near the bottom.

You too can become a "cookbook" chemist! Just follow the "recipe" below.

MEASUREMENT OF DISSOLVED OXYGEN

Two common methods of measuring oxygen gas in water are the Winkler Titration technique and use of the dissolved oxygen meter and electronic probe. The Winkler method is relatively accurate, but requires a number of chemicals and laboratory glassware. Using a dissolved oxygen meter is the most rapid method, but the instrument is expensive.

Winkler Titration Using Hach Chemical Test Kit

1. Collect a 60ml water sample as instructed. Collection must be done carefully to keep oxygen from the air from getting into the water sample.

2. Clip open and add the contents of one capsule of oxygen reagent #1 and one capsule of oxygen reagent #2 to the bottle. Stopper the bottle as directed and invert the bottle several times to mix the chemicals. Let the material settle for a few minutes. Then mix again by inverting the bottle. Let material settle. You now have converted all of the oxygen in your sample to another chemical compound.

3. Add the contents of a capsule of oxygen reagent #3 to the bottle. Stopper bottle and invert until floculant (fluffy or woolly-looking) material dissolves. This chemical releases an amount of iodine, which is yellow equal to the amount of oxygen that was originally in the water.

4. Use the plastic tube as a measuring cup. Fill it to the top with your water sample and pour it into the mixing jar.

5. Swirl the jar gently while adding PAO titrant, one drop at a time. ***Count the drops carefully*** Wait a few seconds before adding each drop. Stop adding the chemical when the water color turns from yellow to colorless. This chemical uses up the iodine and turns the water clear.

6. Each drop of PAO added is equal to one ppm of oxygen. If you added 10 drops of PAO, the water originally contained 10 ppm of O_2.

OXYGEN WORKSHEET

How much oxygen did your sample contain?_____ppm_____

How much oxygen do most fish need to survive?_____ppm_____

Could fish live in this water?_____

PILOT HOUSE TOUR

What is each of these instruments used for:

1. Fathometer _____

_____

_____

2. Compass _____

_____

_____

3. Radar _____

_____

_____

4. Loran - C system and autopilot _____

_____

_____

How deep is the deepest spot in Lake Superior? _____

What is the depth of the water where the boat is now? _____

WATER CHEMISTRY AND PHYSICAL FEATURES

1. The Secchi disk depth here is _____. This means that plants can grow down to a depth of _____.

2. Record the water temperature and oxygen content at different depths.

Depth (m)	Temp. (°C)	Oxygen (ppm)
1		
2		
3		
4		
5		
10		
15		

SECTION II

EXPLORATORIUM ACTIVITIES

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SETTING UP AN EXPLORATORIUM

The SCIENCE WORLD exploratorium was designed to allow students to "explore" a variety of different challenges, experiments and problems that relate to science. Students could pick and choose as they wished. Some of the activities are more time consuming than others, and some students shyed away from those activities. To counteract this problem we divided the activities according to how long it takes to complete them and asked the students to choose activities from both groups. It is important to note that length of time did not necessarily correspond to difficulty. Some of the most time consuming activities were actually quite easy.

Students were encouraged to discover the answer on their own or by discussing it with other classmates. However, a teacher was always present to help and encourage students when they had difficulty. Adult supervision of the exploratorium is essential for obvious reasons. It is a laboratory situation requiring the appropriate safety equipment and precautions.

Possible variations on this concept might include a challenge of the week. Pick one of the activities and allow students to try solving it during their free moments. Another option would be to set up a table with five or six activities and rotate the activities on a weekly basis. Some teachers have converted a storeroom into a permanent exploratorium. There are many possibilities and hopefully the following activities will be helpful to you in setting up your own exploratorium.

EXPLORATORIUM 1

Challenge

Determine the difference between an endothermic reaction and an exothermic reaction.

Background Information

Changes in energy can sometimes be detected by checking for temperature changes. If energy is used in a chemical reaction, the temperature of the substances is lowered. The opposite is also true.

Procedures

CAUTION: The chemicals used in this exploratorium are DANGEROUS and can harm your eyes, skin and clothing.

A. An exothermic reaction
1. Pour 20 ml of dilute nitric acid into a small beaker.
2. Pour 20 ml of dilute sodium hydroxide solution into a small beaker.
3. Place the thermometer into the sodium hydroxide and note the temperature.
4. Pour the nitric acid into the sodium hydroxide and note what happens to the temperature.
5. Rinse off the thermometer with tap water.

B. An endothermic reaction
1. Put 30 ml of tap water into a clean beaker.
2. Place the thermometer into the water and note the temperature.
3. Add one half teaspoon of potassium nitrate to the water and stir with stirring rod.
4. Place the thermometer into the solution and note the change in temperature from step 2.
5. Pour all liquids down the drain, flush the sink with a lot of water and rinse off all glassware that was used.

Materials

3 small beakers
dilute nitric acid
dilute sodium hydroxide solution
potassium nitrate
thermometer
stirring rod
water

Nitric acid (HNO_3) - 70%
1 litre - dilute about 10:1 with water
Potassium nitrate (KNO_3)
need about 2 kg.
Sodium hydroxide pellets - 500g.
mix 30-40 g. with 1000 ml water

EXPLORATORIUM 2

Challenge

Determine the energy flow in different types of materials.

Procedure

1. Cover three flasks - one each with black paper, white paper, and aluminum foil.

2. Insert a thermometer through a stopper (use glycerin in the stopper and a towel over the thermometer) and put one in each flask.

3. Record the temperature in each flask. Move the flasks out into the sunlight (or use a heat lamp) and record the temperature in each flask at one-minute intervals for a period of 15 minutes. Make chart to record data.

Materials

3 250-ml. flasks
black construction paper
white construction paper
aluminum foil
3 1-hole rubber stoppers
3 celsius thermometers
watch or clock
glycerin
towel
sun (heat lamp with stand)
scissors
tape

	Temperature °C		
Minutes	Flask 1 Black Paper	Flask 2 White Paper	Flask 3 Aluminum Foil
Initial temp.			
1 min.			
2 min.			
3 min.			
4 min.			
5 min.			
6 min.			
7 min.			
8 min.			
to 15 min.			

EXPLORATORIUM 3

Challenge

Is it possible for one balloon to blow up another?

Procedure

1. Blow up two identical balloons, blowing one more than the other.
2. Join the two balloons tightly together by a short length of rubber tubing. (take care that air does not leak out until the balloons are tightly joined.)
3. Secure the balloons to the tubing using tape or string.
4. Release the air in the two balloons.
5. What happened?
6. Does the smaller balloon expand at the expense of the larger one?
7. How can you explain what you have observed?

Materials

Two balloons
Piece of rubber tubing

*from "The Flying Circus of Physics" by Jearl Walker

EXPLORATORIUM 4

Challenge

Does time have weight?

Procedure

1. Place an hourglass on each pan of the balance. (Make sure the sand is in the bottom of each.)
2. Adjust the riders to bring the pointer in balance.
3. Tip over an hourglass. Does it weigh less?
4. Does the weight of an hourglass depend on whether the sand is flowing?

   If some of the sand is in free fall, won't the weight of the hourglass be less?
5. Explain your answer.

Materials

Balance
Two hourglasses

*from "The Flying Circus of Physics" by Jearl Walker

EXPLORATORIUM 5

Challenge

Gently remove the plastic bag from the jar. Do not remove the rubber band or put a hole in the bag.

Questions

1. What happens?

2. Can you explain why this happens?

Materials

Jar
rubber band
small plastic bag

Note to Teacher

Place a plastic bag inside of a jar with the opening of the bag folded back over the mouth of the jar. Secure the bag to the jar with several rubber bands so that no air can leak in between the jar and plastic bag.

EXPLORATORIUM 6

Challenge

Can you design a pendulum that takes 1.5 seconds to move back and forth?

Procedure

1. Use any combination of materials and/or length of string to construct your pendulum.

2. Use a stop watch to time your clock for ten complete swings.

Question

What would you do to get a pendulum with a complete swing of 1 second?

Materials

String
Material for pendulum bob
Stand to hold pendulum

EXPLORATORIUM 7

Challenge

You must locate a sound not created intentionally by you or others that registers 90 decibels on the decibel meter.

Background Information

Sound is measured in the unit-decibel; a level of 80 over a period of time causes hearing loss. A jet at take-off as well as a Black Sabbath concert will register 120 dB.

Procedure

Use the decibel meter to find:

1. The sound level of a bird singing.
2. The sound level of the crowd at meal time.
3. A sound not created by you or others that registers 90 dB.

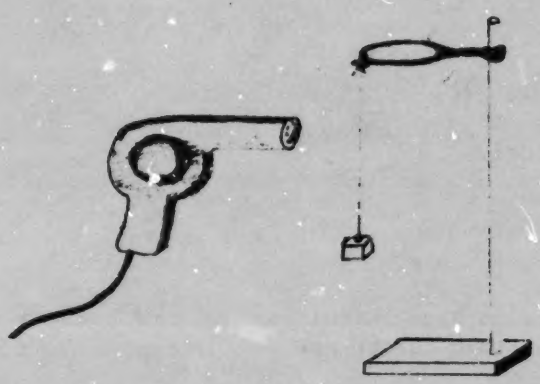
Material

Decibel meter

EXPLORATORIUM 8

Challenge

Predict what will happen to a stretched, weighted rubber band when heated.



Procedure

1. Make your hypothesis
2. Take a rubber band and place it on the ringstand as shown.
3. Add several mass units to extend the rubber band.
4. Plug in the hair dryer and apply the heated air to the rubber band just above the mass units.
5. Record your results.

Materials

Ringstand
Clamp with rod
Rubber band with ¼" width
Paper clip
Mass units
Hair dryer

EXPLORATORIUM 9

Challenge

Make a clay boat that will carry the most mass (weight)

Procedure

1. Weigh out 50 grams of clay.
2. Shape clay into a boat.
3. Float boat in water.
4. Add marbles until boat sinks.
5. Record the number of marbles needed to sink your boat in your notebook and on the bulletin board on the wall.

Materials

Clay
Water tank
Marbles
Balance

EXPLORATORIUM 10

Challenge

To explain an unusual property of rubber

Background

Rubber is a polymeric material that can be obtained either from natural resources or by chemical synthesis. It consists of very large molecules made up of long chains of atoms. Most useful rubbery materials also have been treated with sulfur (or vulcanized, a process first performed by Charles Goodyear in 1939) where the sulfur acts as bridges or crosslinks between the long molecules. Because of this unique molecular structure, rubber has many unusual properties.

Procedure

1. Hold a rubber band with the forefinger and thumb of both hands.
2. Touch the rubber band to your lips, note the approximate temperature of the rubber band.
3. Quickly stretch the rubber band and immediately touch the stretched rubber band to your lip to again sense the temperature.
4. What do you observe?
5. Now release the rubber band and quickly touch it to your lip. Again note the change in temperature.
6. What do you observe?
7. A stretched rubber band has less energy than an unstretched rubber band. Use this information to explain the above observations.

Materials

Rubber band

EXPLORATORIUM 11

Challenge

Determine how objects of different mass accelerate in response to the force of gravity.

Procedure

1. Find the mass of the two steel balls.
2. Drop each steel ball from ring level to catch box and record time.
3. Compare the times.
4. Repeat procedures 1, 2, and 3 using other objects.

Materials

Balance
Two (2) steel balls of different mass
Watch
Ring stand
Catch box

EXPLORATORIUM 12

Challenge

Determine how to separate a mixture of salt, sand and pins.

Background Information

A mixture is formed when substances combine without changing chemically. Each component or ingredient of a mixture retains its own identity and properties. Physical changes are used to separate the components of a mixture.

Procedures

1. Put on your goggles!
2. Measure out 50 ml. of sample.
3. Describe how you separated out each part of the mixture.

Materials

funnel
sieve
filter paper
heat source
evaporating dish
magnet
mixture of salt
sand
common pins
Pyrex beaker
water
ring stand
wire gauze
ring clamp
heat source

EXPLORATORIUM 13

Challenge

Confirm The Law of Conservation of Mass and determine the mass of a gas produced during a reaction.

Background Information

The Law of Conservation of Mass states: the mass of the reactants in any chemical reaction equals the mass of the products. Sometimes the products of a chemical reaction look different from the reactants. If a gas is produced, you may not see it. Yet, its mass must be taken into account in finding the total mass of the products. The law of conservation of mass is an important law of chemistry. This laws holds true for all chemical reactions.

Procedure

1. Put on goggles!
2. Measure 70 ml of water using a graduated cylinder and add it to the flask. Use ¼ of a piece of seltzer tablet.
3. Determine the total mass of the seltzer tablet, flask with water and the stopper on the balance. Record this value in your data table.
4. Remove the bottle from the balance. Place the piece of seltzer tablet you massed in the bottle. Quickly stopper the bottle tightly. Following the reaction, determine the mass of the bottle, stopper and contents. Record the mass in your data table.
5. Did the total mass change after the reaction as compared to before the reaction?
6. Remove the stopper so the gas escapes. Place the stopper on the balance along with the bottle. Determine and record the mass of the bottle and stopper following the escape of gas.
7. What is the mass of the gas that escaped from the bottle? What gas do you think was produced?
8. Use your answer from question 7 to calculate the mass of gas that would be produced if the whole tablet had reacted.

Materials

Balance	Stopper to fit bottle or flask
Bottle or flask	Water
Seltzer Tablet	Graduated cylinder

EXPLORATORIUM 14

Challenge

Determining if oxygen is releaded from a reaction

Procedure

1. Put on goggles!
2. Fill the baby food jar with 50 ml of hydrogen peroxide (H_2O_2).
3. Add ½ teaspoon of manganese dioxide (MnO_2).
4. Put the lid on the jar.
5. Light the toothpick and blow it out for a glowing splint.
6. Put the glowing splint over the hole in the lid.
7. Observe the splint. (Agitate the jar if it doesn't ignite).
   a. Does the splint ignite?
   b. Where does the oxygen come from?
   c. What is a catalyst?

Equation: $2\ H_2O_2 \xrightarrow{MnO_2} 2\ H_2O + O_2$

Materials

baby food jar with lid
hydrogen peroxide
manganese dioxide
toothpick or wood splint
matches

EXPLORATORIUM 15

Challenge

To demonstrate how the fluid in living tissue can be an electrolyte.

Background Information

The working of a simple cell of this type depends upon two factors. First, the metal must be dissimilar; that is, they must be of different types. Second, the fluid in which they are placed must be capable of conducting electricity. A fluid of this type is called an electrolyte.

A chemical reaction takes place between the two metals (electrodes) and the electrolyte.

Procedure

1. Puncture the ends of two strips of metal of different types, and attach to the galvanometer by means of the copper wire.

2. Insert the metal strips into various fruits and record the reading of the galvanometer.

3. Try different metals and different fruits.

4. Are some combinations better than others?

5. Touch the two pieces of clean metal to opposite sides of your tongue. What is the reading on the galvanometer?

6. Repeat this activity, using various combinations of metals. Describe your results.

Materials

Sensitive Galvanometer
Several short pieces of copper bell wire
Variety of fruits (including a lemon)
Strips of different metals (including copper, iron, and zinc)

EXPLORATORIUM 16

Challenge

What is the temperature of ice when it melts?

Procedure

1. Ice cubes are available in the refrigerator. Break one cube into pieces that will fit into the test tube until about 2/3 full. (Put the ice between sheets of paper towel and break it up using a hammer). Add 1/2 test tube of water.

2. Insert a thermometer into the ice water.

3. Hold your hand around the test tube to heat it.

4. Begin recording the temperature immediately. Record the temperature every 15 seconds.

5. Continue heating by holding the test tube until all of the ice is melted.

6. What is the temperature of ice when it is melting?

7. Graph the data you have collected.

8. What happens to the heat supplied by your hand when the ice is melting?

Materials

Ice
Large test tube
Celcius thermometer
Graph paper
Hammer
Paper Towel

EXPLORATORIUM 17

Challenge

Determine why salt is put on icy roads

Background

A common practice in the winter is to have salt spread on ice or snow covered streets and sidewalks.

Procedure

1. Fill a container with crushed ice and record its temperature.
2. Add two spoons full of salt to the ice and stir a little.
3. Take the temperature of the mixture every minute for 15-20 minutes. Observe and note conditions.
4. Graph the temperature readings.
5. What general statement can you make concerning the relationship between ice and salt? Where else might you apply this relationship?

Materials

Ice
Salt
Celsius Thermometer
Clock
Beaker
Spoon

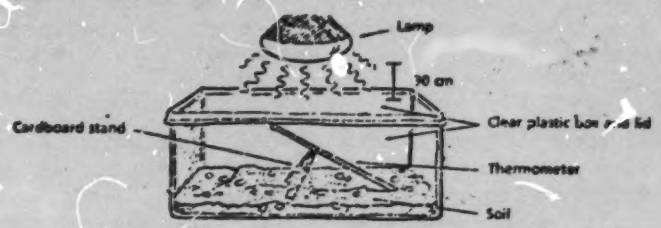
EXPLORATORIUM 18

Challenge

Determine one reason why the surface temperature on Venus has been measured around 460° C . . . the greenhouse effect.

Background

The surface of Venus is constantly covered with thick clouds. The heat given off from the sun is trapped beneath these clouds and causes the planet's high temperatures.



Procedure

1. Place 3 cm of soil in the bottom of a clear plastic box.
2. Thoroughly moisten the soil with water.
3. Set up the equipment as shown above. Put the lid on the box.
4. Position the box outside in the sun or adjust a lamp 30 cm above the box.
5. Record the temperature every minute for 20 minutes in your notebook.
6. Allow the thermometer to return to room temperature.
7. Remoisten the soil and repeat with the lid off the box.

Materials

Meter stick
cardboard
sun (heat lamp)
ring stand
clear plastic storage box and lid
soil
water
celsuis thermometer
watch

EXPLORATORIUM 19

Challenge

Explain how to control the sinking and rising of a medicine dropper in a graduate full of water.

How can pressure on the surface of the water in the graduate have an effect on the medicine dropper moving up and down?

Procedure

1. Fill a medicine dropper with water so that there is between 2.5 and 3.0 cm of water in the glass tube of the dropper. Put the dropper into a beaker of water. It should float. If the medicine dropper sinks to the bottom of the beaker, take the dropper out of the water. Remove two or three drops of water from the dropper and try to float it again in the beaker.

2. Pour water into a 100 ml graduate until the water is about 3.0 cm from the top. Take the dropper from the beaker and put it into the graduate. (Be sure that the dropper is still floating). Add enough water to the graduate to fill it to the top. Place the palm of your hand over the top of the graduate and GENTLY apply pressure. As you increase the pressure of your hand on the water surface, the medicine dropper should sink. By controlling the amount of pressure, you should be able to make the dropper sink to the bottom, rise to the top, or stay in the middle of the cylinder.

3. If you cannot make the medicine dropper sink by applying pressure, then you do not have enough water in the dropper tube. Take the dropper out of the water and increase the amount of water inside the tube by a very small amount. The amount of water in the dropper is the fact that controls its moving up and down. You may have to either add or subtract small amounts of water from the dropper tube until it is working correctly.

Materials

Large container of water
Medicine dropper
Graduated cylinder

EXPLORATORIUM 20

Challenge

Determine if the total mass is conserved when two liquids are mixed to form a new liquid and a precipitate

Procedure

1. Put on goggles!
2. Fill vial #1 with sodium iodide (NaI) to 1/3 full.
3. Fill vial #2 with lead nitrate ($Pb[NO_3]_2$) to 1/3 full.
4. Determine the combined mass of vials 1 and 2 with contents.
5. Pour the liquid of vial 1 into vial 2. Note the reaction.
6. Determine the mass of the new liquid and precipitate along with the mass of the now empty vial 2.
7. Record data.
   Mass before reaction _____ g
   Mass after reaction _____ g
8. Wash hands after handling.

Materials

2 vials w/caps
Sodium Iodide
Lead Nitrate
Balance

$$2\ NaI + Pb(NO_3)_2 \longrightarrow 2\ NaNO_3 + PbI_2$$

(Yellow precipitate)

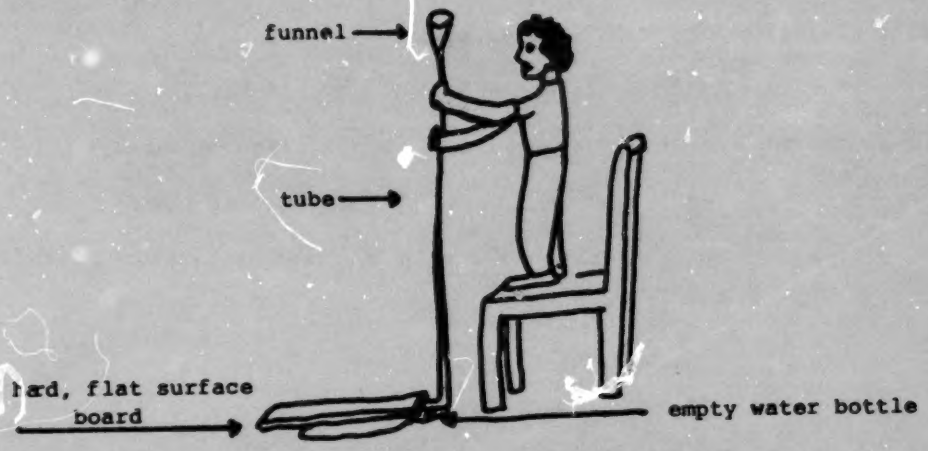
EXPLORATORIUM 21

Challenge

How much weight can you lift using 500 ml. of water?

Procedure

1. Set up the equipment as shown in the diagram. The tube must be fully extended.



2. Ask a classmate, teacher or someone else to stand on the hard surface. Slowly pour the 500 ml. of water steadily into the funnel. As the water goes into the water bottle, what happens to the person on the hard surface?

3. Design your own experiment now to answer one or more of these questions.

   a. What is the heaviest object you can lift with 500 ml. of water?

   b. What will happen if you shorten the length of the tube?

Materials

Water bottle
Tubing
Funnel
Hard, flat surface (such as a board)
Water, 500 ml.
Meter stick

EXPLORATORIUM 22

Challenge

How many books can you move?

Procedure

1. Connect the tube to the end of the 6 cc syringe. Put the end of the tube into the container of water. Pull back on the plunger. Fill the tube and syringe with water. Water should fill the tube and syringe with a minimum of air bubbles. You will have to work to get rid of the bubbles.

2. Connect the tube to an empty 6 cc syringe.

3. Slowly push down on the filled syringe.

4. What happens to the plunger on the other end of the system?

5. You can use your syringe set-up to push books. Follow the diagram below. How many books can you push? Record in your data table.

6. Repeat the above and connect the tube to a 10 cc syringe and again to a 30 cc syringe in the push syringe position.

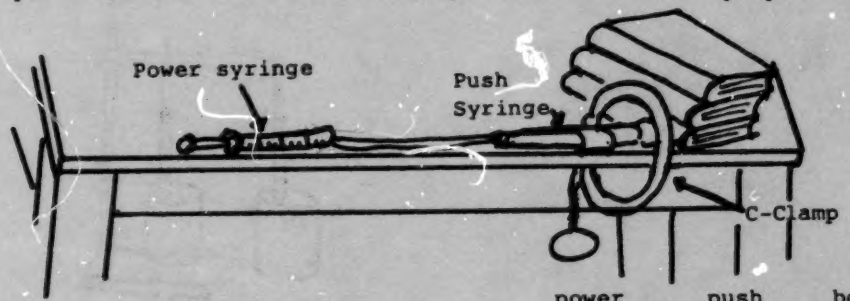
7. How many books can you push with these syringes? Record in your data table.

8. What will happen if you change the power syringe to a 30 cc and the push to a 6 cc syringe?

9. What will happen if you change the power syringe to a 30 cc and the push syringe to a 30 cc?

10. What set-up will give the most power?

11. Can you think where Pascal's Rule would be used in everyday life?



power syringe	push syringe	books pushed
6cc	6cc	
6cc	10cc	
6cc	30cc	
30cc	6cc	
30cc	30cc	

Materials

Plastic syringes-6 cc, 10 cc, 30 cc
Tubing (20 cm)
Container of water
Pile of textbooks

EXPLORATORIUM 23

Challenge

Storing heat energy

Procedure

1. Fill the two containers, one with dry soil and the other with water.

2. Tie the two thermometers to the iron ring and place the bulb end of the thermometer just beneath the surface of the water. Do the same for the second thermometer in the container of soil.

3. If you use the heat lamp attach it to the second iron ring stand and adjust above the containers so both are receiving the same amount of heat. If it is a sunny day and you use the solar energy outside, you will not use the heat lamp.

4. Wait five minutes for the temperature to stabilize.

5. Record the temperature of both soil and water each minute for a fifteen minute period.

6. After fifteen minutes, turn the light off (if outside, take containers and apparatus inside and continue to record readings for fifteen more minutes).

7. Graph results on the graph paper.

Materials

2 containers
2 thermometers
lamp or sun
iron ring/stand (2)
soil
water
watch
string
ruler
pencil
graph paper

EXPLORATORIUM 24

Challenge

Determine energy transfer and retention in four types of natural materials

Procedure

1. Fill plastic trays, each with one of the following natural materials: sand, black soil, rocks, and water.

2. Place a thermometer in each tray so that the bulb is well covered by the natural macerial.

3. Record the temperature (make a chart as shown below to record data). Place all four trays in the sun (use heat lamp if necessary). Record the temperature at one minute intervals for a period of 15 minutes.

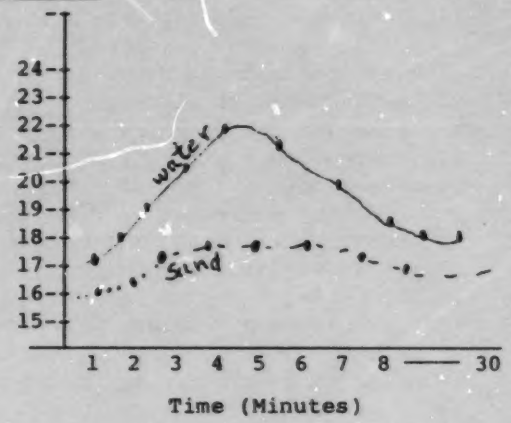
4. Remove trays from the sun (inside or in the shade), and continue to record the temperature at one minute intervals for a period of 15 minutes.

5. Make a graph which compares your results. See example.

Data — Temp. °C

Time		Sand	Soil	Rocks	Water
Initial Temp.					
Sun	1 min				
	2 min				
	3 min				
	4 min				
	5 min				
	15 min				
Out of Sun					
	1 min				
	2 min				
	3 min				
	4 min				
	5 min				
	15 min				

Graph example



Materials

4 plastic trays	sand	black soil
rocks	water	4 celsius thermometers
stopwatch	graph paper	sun (heat lamp is sun isn't shining)

Challenge

Complete the matching exercise below.

Procedure

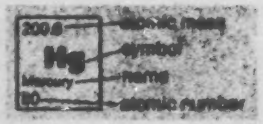
In the LEFT COLUMN, determine the correct numbers in each item and multiply, divide, add, or subtract as indicated. Then, match the numbers with the appropriate numbers in the RIGHT COLUMN. Use the atomic number of the elements unless indicated otherwise. (At. wt. means atomic weight). When the answer is determined, place letter from right column in front of number in left column.

LEFT COLUMN	RIGHT COLUMN
___1. the senses + Boron	A. unlucky number
___2. wisdom teeth x protons in HE	B. weeks in the year
___3. baseball team + oxygen	C. number of electrons in lead
___4. Gadolinium ÷ 4	D. at. wt. = 20
___5. astronauts in an Apollo flight x phosphorus + helium	E. named after the state where the "Dodgers" play
___6. hexagon + tetrahedron	F. planet that Superman came from (an element)
___7. Argon - Zodiac signs	G. the Commandments
___8. known planets ÷ protons in lithium	H. period that Cobalt is in
___9. Fermium ÷ 10 + triangle sides	I. golf course holes
__10. chambers in human heart x carbon + number of moons	J. blackbirds baked in pie
__11. pentagon sides x electrons in outer shell of nitrogen	K. 5 cent coin in element #?
__12. Snow White's dwarfs + the ___ seas	L. octopus arms
__13. degrees in a circle ÷ Thorium	M. period that Mg and Al are in?
__14. freezing point (F) of H_2O - freezing point (C) of H_2O	N. second atom in NaCl
__15. neon x the - seasons in Wi. x the lightest inert gas	O. element named after author of $E=mc^2$
__16. disciples x He	P. element that is a "silly con"
__17. At. wt. of U - Golden Anniversary -106	Q. Iodine - Scandium
__18. bits in a half dollar x days in a week	R. Zinc
__19. sides of a quadrangle x lives of a cat	S. Mn
__20. football team (defense) x gas in atmosphere (79%) + Boron	T. points on a star
__21. number of elements in Noble family x B	U. atomic number of yellow element
__22. At. number of Li + Na + Be	V. Latin name argentum; best conductor
__23. element named after Mendeleev - moons around Mars	W. part of hemoglobin; Latin name ferrum
__24. At. Wt. of C + Zirconium	X. element found in thermometer and barometers
__25. neutrons in Potassium x 5 - 2	Y. Latin name plumbum; used to drain baths of ancient Rome

Materials

Pencil
Periodic chart

PERIODIC TABLE OF THE ELEMENTS



																4.00 He Helium 2
6.94 Li Lithium 3	9.01 Be Beryllium 4											10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
23.0 Na Sodium 11	24.3 Mg Magnesium 12											27.0 Al Aluminum 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	39.9 Ar Argon 18
39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101.1 Ru Ruthenium 44	102.9 Rh Rhodium 45	106.4 Pd Palladium 46	107.9 Ag Silver 47	112.4 Cd Cadmium 48	114.8 In Indium 49	118.7 Sn Tin 50	121.8 Sb Antimony 51	127.6 Te Tellurium 52	126.9 I Iodine 53	131.3 Xe Xenon 54
132.9 Cs Cesium 55	137.3 Ba Barium 56	138.9 La* Lanthanum 57	178.5 Hf Hafnium 72	180.9 Ta Tantalum 73	183.8 W Tungsten 74	186.2 Re Rhenium 75	190.2 Os Osmium 76	192.2 Ir Iridium 77	195.1 Pt Platinum 78	197.0 Au Gold 79	200.6 Hg Mercury 80	204.4 Tl Thallium 81	207.2 Pb Lead 82	209.0 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
(223) Fr Francium 87	226.0 Ra Radium 88	(227) Ac† Actinium 89	# 104	# 105													

*	140.1 Ce Cerium 58	140.9 Pr Praseodymium 59	144.2 Nd Neodymium 60	(145) Pm Promethium 61	150.4 Sm Samarium 62	152.0 Eu Europium 63	157.3 Gd Gadolinium 64	158.9 Tb Terbium 65	162.5 Dy Dysprosium 66	164.9 Ho Holmium 67	167.3 Er Erbium 68	168.9 Tm Thulium 69	173.0 Yb Ytterbium 70	175.0 Lu Lutetium 71
†	232.0 Th Thorium 90	231.0 Pa Protactinium 91	238.0 U Uranium 92	237.0 Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(245) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(254) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103

The most stable known isotopes are shown in parentheses.

The discovery of elements 104 and 105 has been claimed by both American and Russian scientists. The Americans have suggested the names *rutherfordium* and *hahnium*; the Russians have suggested the names *kurchatovium* and *nielsbohrium*.

EXPLORATORIUM 26

Challenge

Make a sundial and prove that it works

Background

The Earth is a sphere and it rotates on its axis once very 24 hours. Can the Earth be used as a clock?

Procedure

Orient and determine the position of the 13 hour stakes (6:00 a.m. to 6:00 p.m.) around the taller shadow stake.

Check the location of the hour stakes with a watch. Is your watch on suntime?

Materials

Magnetic Compass
1 long stake
13 short stakes
Watch

EXPLORATORIUM 27

Challenge

Learn to recognize at least ten constellations that appear in the July sky.

Procedure

1. Select the tagboard patterns for the constellations that you want to learn.

2. Make your own set of constellation slides by using a sharp probe or needle to punch a hole through each of the stars in the individual constellation patterns.

3. Be sure to write the name of the constellation and the general direction (either north or south) on your own slide.

4. Also trace the outline of each constellation.

5. Take your constellation pattern home.

6. After dark insert one of the constellation slides into a slide viewer. Standing in the general direction indicated on your slide, study the constellation that appears in the viewer and match it up with the actual constellation in the sky.

Materials

Ten 5 cm by 5 cm tagboard squares
Sharp probe or needle
Pen or pencil
Set of constellation patterns (Available in astronomy books)
Cardboard backing board
Slide viewer

EXPLORATORIUM 28

CHALLENGE

Construct a sun dial to tell time.

BACKGROUND

People have been marking time by the sun for many millenia. Gradually, after careful observation, they worked out ways to divide days using shadow devices. But no matter how ingenious they were, people still had to adjust their timekeeping for longer days in the summer and shorter days in the winter.

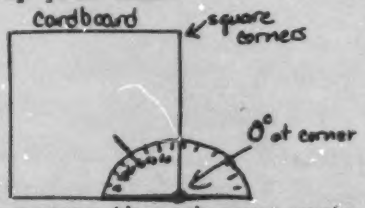
If you lived on the north pole, a sundial flat on the ground would be perfect. If you don't you must tilt your sundial so it faces the sun at the same angle as the one on the north pole.

PROCEDURE

1. Using the atlas, find your latitude.

2. Subtract your answer from 90°. The resulting number of degrees is the angle at which you must tilt your sun dial. Example: $\begin{array}{r} 90° \\ -\ 50° \\ \hline 40° \end{array}$

3. Make two cardboard wedges to prop your dial.
   a- mark your angle.



   b- draw a line 4" long from the corner through your mark.
   c- cut out the two angle wedges.

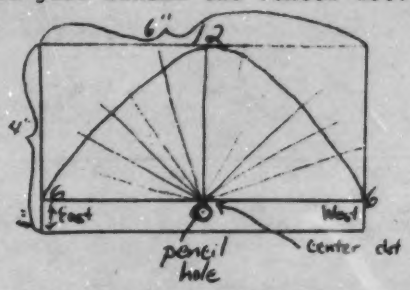
4. Cut a rectangle top out of cardboard measuring 4" x 6"

5. Make the face of your dial.

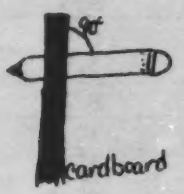
   a- draw a line lengthwise 1" from one side, and make a dot in the center of the line.

   b- using the protractor, divide a half-circle into 12 equal parts.

   c- make a pencil hole just behind the center dot.



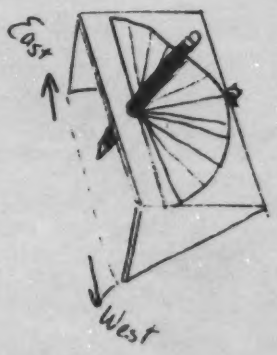
6. Insert the pencil next to the center dot, make sure it is upright, at a 90° angle.



7. Using masking tape, tape the wedges to the face.

8. To use: Line the sundial east to west (see diagram), with the face of the dial facing the sun. (Use compass for accruacy).

   Label the hours on your sundial with 12 time divisions. Tell time!



MATERIALS

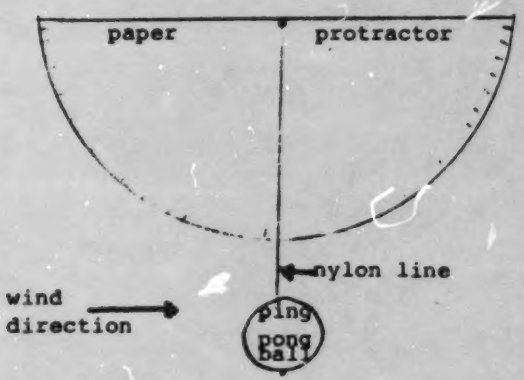
Small piece of cardboard
single-edge razor blade
protractor
Atlas
felt-tip pen
masking tape
pencil
compass (optional)

CHALLENGE

Evaluate the wind as a source of energy.

PROCEDURE

1. Cut out a paper copy of a protractor and glue it to a piece of cardboard.
2. Thread a needle with nylon line and push the needle through the ping pong ball; tie a knot in the line so it won't slip back through.
3. Glue or tape line to base of protractor (see diagram).
4. Color the line with magic marker.
5. Calibrate the wind speed like this:



Angle	mph	km/hr
0	0	0
5	5.8	9.6
10	8.2	13
15	10.1	16
20	11.8	19.2
25	13.4	20.8
30	14.9	24
35	16.4	25.6
40	17.8	28.8
45	19.6	32
50	21.4	33.6
55	23.4	36.8
60	25.8	41.6
65	28.7	46.4
70	32.5	52.8

MATERIALS

ping pong ball
30 cm nylon thread
copy of a protractor
magic marker
scissors
glue
needle
7" x 4" piece of tag board

EXPLORATORIUM 30

CHALLENGE

Try to stick a pin in a balloon without breaking the balloon.

PROCEDURE

1. Blow up a balloon.
2. Tie a knot in the balloon's neck.
3. Try to stick a pin into the balloon.
4. Remove the pin.
5. Break and throw away the balloon.
6. Please don't help others (limit of three chances).

MATERIALS

Balloon
Straight pin

EXPLORATORIUM 31

CHALLENGE

One night while you are asleep, the entire universe and everything in it becomes 1000 times larger. Your challenge is to prove that a change has occurred.

BACKGROUND

Remember that everything increases in size including your body, electrons, planets, rulers, etc.

PROCEDURE

Summarize your methods of proof on the "IDEA SHEETS" that are provided and leave them in the box. You may want to look at the ideas other students have submitted. At the end of the week, the answer to this problem will be revealed.

MATERIALS

Idea Sheets
One box

ANSWER

According to Henri Poincare, the 19th century mathematician who devised this problem, there is no way to prove this. It is meaningless to say the universe grew larger since the word "larger" means larger in relation to something else. When talking about the universe, there is no "something else" to compare to. Space is defined relative to the measures people create.

EXPLORATORIUM 32

CHALLENGE

How much is a million?

PROCEDURE

Estimate the answer for each of the following questions. Compare your estimates with the correct answers on the back of this sheet.

1. How old are you when you have lived one million seconds?

2. If you took one million steps, how many miles did you travel?

3. On what page is the one millionth word in A Sand County Almanac?

ANSWERS

1. About 11½ days old.

2. Assuming you moved two feet per step, you would travel 379 miles. If you live in the southern part of Wisconsin, it would take you about one million steps to get home from Science World.

3. Sorry, Aldo Leopold did not get to the one millionth word in writing A Sand County Almanac. This book only contains 80-90,000 words. It would take ten more books like this one to total one million words.

   As a further note of interest, it would take over 3,000 copies of A Sand County Almanac to total one million pages, a stack over 275 feet high.

EXPLORATORIUM 33

CHALLENGE

Using six pencils, make four equal triangles. The angles must be formed by the ends of the pencils.

MATERIALS

Six pencils

EXPLORATORIUM 34

CHALLENGE

Is $5.98 a good deal for Amazing Southern European Air Worms Kit?

BACKGROUND

This ad was found in the back of a magazine.

AMAZING SOUTHERN EUROPEAN
AIR WORMS KIT

Cryogenically preserved segments of imported Southern European Air Worms will miraculously spring to life when combined with tap water and life instilling Vitae Powder and Vitae Liquid. Thrill to the sight of seeing the air worms jump, swim, and locomote through the life sustaining liquid. Exciting! Mysterious! Rare! Scientific! Educational! And at $5.98 a real bargain. Supplies are limited. Unavailable from any other U.S. Company. Allow 6-8 weeks for delivery.

PROCEDURE

We have acquired large quantities of air worm segments, Vitae Powder and Vitae Liquid. Put about 700 ml. of tap water into a 1000 ml. beaker. Add 10-15 segments of air worms. Dissolve about 10 grams of Vitae Powder in the tap water. Quickly pouring (all at once) about 40 ml. of Vitae Liquid. Observe. You may want to add a few extra ml. (2-10) of Vitae Liquid. Record your observations in your notebook. Discuss your findings with the exploratorium teacher. Answer the challenge question. Clean all materials and dispose of air worms properly.

MATERIALS

10-15 segments of air worms
10 g. Vitae Powder
40-50 ml. Vitae Liquid
1000 ml. beaker
glass stirring rod

Southern Air Worm Explanation Page

Teacher notes on Southern European Air Worms

Vitae Powder = Baking soda

Vitae Liquid = Vinegar

Air Worms = Pieces of spaghetti (whole wheat or spinach may look better)

The strands of spaghetti will rise and fall appearing to be "alive."

There are several possibilities for discussion; truth in advertising, characteristics of living things, powers of observation, etc.

EXPLORATORIUM 35

CHALLENGE

To decode the phone numbers of those scientists listed below (as if they had phones way back when...) and place answers on a page in your record book.

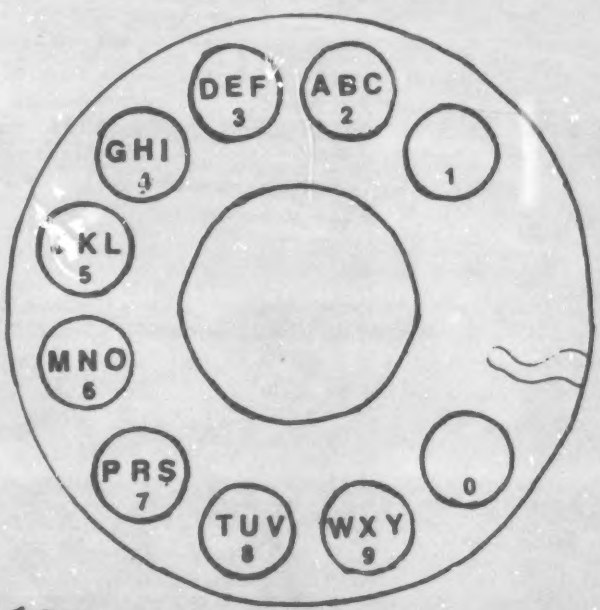
BACKGROUND

Perhaps the stereotype of the absentminded (science) professor is correct. Take, for example, the fact that throughout history scientists have requested to have telephone numbers that are easy to remember because they spell out a word or words corresponding to the letters on the phone dial. For instance, Alexander Graham Bell's phone number was 976-6466 (wrong no.), and Hans Oersted's was 624-6387 (magnets). Can you decode the numbers of the following scientists?

MATERIALS

Background information sheet

1.	Charles Darwin	666-5397	
2.	Louis Pasteur	468-6455	
3.	Robert Goddard	762-5387	
4.	Nuclear Regulatory Commission	456-9464	
5.	Food and Drug Administration	226-2377	
6.	Johann Kepler	782-7529	
7.	Isaac Newton	472-8489	
8.	Wright Brothers	359-2697	
9.	Wernher Von Braun	243-7626	
10.	Marie Curie	522-5239	
11.	Anders Celsius	468-2653	
12.	Neil Armstrong	666-6626	
13.	John Scopes	466-3273	
14.	Thomas Edison	636-5675	
15.	Watson-Crick	362-2645	
16.	Dimitri Mendeleev	737-4637	
17.	Copernicus	765-2747	
18.	Galileo	786-7768	
19.	Rachel Carson	764-7667	
20.	George Washington Carver	732-6887	



BACKGROUND INFORMATION SHEET

DARWIN-responsible for the theory of evolution to account for the origin of species in terms of natural selection with variation; the idea that man evolved from lower organisms (i.e. primates).

PASTEUR-a French biochemist who developed the process of "pasteurization"--to heat Milk or other liquids in order to kill disease bacteria and prevent deterioration.

GODDARD-the father of U.S. rocketry; in the late 1890's he speculated on means of reaching the fringes of outer space by the use of rockets. He discovered that rockets operated better in a vacuum than in the atmosphere.

NUCLEAR REGULATORY COMMISSION-the federal agency created by the U.S. Congress to direct and control the production of and use of atomic energy for national defense and for a wide variety of peaceful applications in such fields as biology, medicine, health, agriculture and industry.

FOOD & DRUG ADMINISTRATION-an agency of the U.S. Government in the Department of Health and Social Services. Its prime purpose is to protect citizens against harmful, unsanitary, or falsely labeled foods, drugs, cosmetics or the therapeutic devices.

KEPLER-a mathematician, physicist and astronomer famous for his three laws of planetary (star) motion.

NEWTON-a British physicist and mathematician who discovered that any two bodies attract each other with a force proportional to the product of their masses divided by the square of the distance between them.

WRIGHT BROS.-producers of the first successful aeroplane: their glider was tested at Kittyhawk in 1902 in nearly 1000 gliding flights and later they developed larger and more powerful aircraft.

CURIE-a female scientist who spent most of her life doing laboratory research on radioactivity; she was responsible for studying radioactive decay rates in such substances as radium.

CELSIUS-an astronomer who was chiefly remembered for his work with temperatures--and the creator of the centigrade (celsius) thermometer scale.

ARMSTRONG-the most famous of the 3 astronaut team who in July of 1969 was accredited with being the first man to step foot on the moon. His words were, "One small step for man.....one giant leap for mankind."

CALLING ALL SCIENTISTS ANSWER SHEET

1. Chas Darwin - Monkeys
2. Louis Pasteur - Hot Milk
3. Robert Goddard - Rockets
4. Nuclear Reg. Com. - Glowing
5. FDA - Cancers
6. Johann Kepler - Star Law
7. Isaac Newton - Gravity
8. Wright Brothers - Fly Boys
9. Wernher Von Braun - A German
10. Marie Curie - Lab Lady
11. Anders Celsius - Hot Cold
12. Neil Armstrong - Moon Man
13. John Scopes - Gone Ape
14. Thomas Edison - New Bulb
15. Watson-Crick - DNA Coil
16. Dimitri Mendeleev - Periods
17. Copernicus - Polaris
18. Galileo - Sun Spot
19. Rachel Carson - Poisons
20. George Washington Carver - Peanuts

EXPLORATORIUM 36

CHALLENGE

Find out the amount of oxygen that you exhale during various types of activities.

PROCEDURE

1. Push equal amounts of steel wool into the bottoms of the test tubes. Weigh and record the measurement for each test tube and its contents.

2. Fill the test tubes with water and invert them in a pan of water.

3. After each activity exhale your breath into a different test tube. Make sure that you use this procedure. . . .keeping test tube inverted under water, open test tube end. . . .exhale air into tube, displacing water, stop exhaling when water is out of tube, then replace stopper.

4. Heat test tube until completely dry.

5. Remove carbon.

6. Re-weigh each test tube.

7. Compare the original weight of each test tube with its final weight to determine how much oxygen combined with the steel wool and the amount that was in the breath that you exhaled.

MATERIALS

Test tubes numbered for identification
Test tube holder
Test tube clamp
Ring stand
Test tube stoppers
Heat source (propane burner)
Grease marking pencil
Pan partially filled with water
Steel wool
Rubber tubing
Laboratory balance
Paper towels

EXPLORATORIUM 37

CHALLENGE

Find out how exercise affects the amount of Carbon Dioxide (CO_2) you exhale.

BACKGROUND

Carbon dioxide (CO_2) chemically reacts with calcium hydroxide ($Ca(OH)_2$) to form limestone ($CaCo_3$). Because limestone will not dissolve in water, it settles out as a precipitate. When more carbon dioxide is present, more limestone will form.

PROCEDURE

1. Fill each test tube one-half full with $Ca(OH)_2$ (calcium hydroxide) solution.
2. GENTLY blow two full breaths into test tube #1 using the straw.
3. Run in place for 5 minutes.
4. GENTLY blow two full breaths into test tube #2 using the straw.
5. Set the test tubes aside for AT LEAST ONE HOUR then, without disturbing the contents, compare the amounts of limestone that has settled to the bottom.
6. Try leaving the tubes overnight.

MATERIALS

Straw
Test tubes. . . . labeled #1 and #2 (also with your name)
$Ca(OH)_2$ solution (calcium hydroxide)

EXPLORATORIUM 38

CHALLENGE

Determine the economic value of a tree

BACKGROUND

Frequently, the courts must decide how much a tree is worth to settle claims. In this exploratorium, you will be using the same procedure used in court.

PROCEDURE

1. Obtain handouts entitled, "How much is your tree worth?" "Trunk Diameters," etc.
2. Select a nearby tree.
3. Determine its worth - it's more than you think!

MATERIALS

Handouts
Meter stick

HOW MUCH IS YOUR TREE WORTH?

Where do you think a tree would be worth more money: in the forest or in the city? 1 _____

Now let's try to find out how much money a city tree is worth. Look at the drawings of Kaukauna trees given by your instructor. Use the drawings to identify the tree with which you are working. Do not try to work with a tree that is not found in pictures.

In order to find the money value of a tree you must first find the circumference of the tree (distance around trunk). 2 _____

Now measure the circumference of the tree trunk 4½ feet above ground. (Circumference is the distance around a circle.) What was the circumference of your tree 4½ feet above the ground? 3 _____

Now look on the chart entitled, "Trunk Diameters and Area of Trunk Cross Sections." Find your circumference and follow across the page. The chart will then give you the answers to number 4 and 5. What is the diameter of your tree 4½ feet above the ground? 4 _____

Now that you have the diameter, look at the chart called "Trunk Diameters and Area of Trunk Cross-Sections" again. This chart will also give you the cross-section area in square inches of your tree. What is the cross-section in square inches of your tree? 5 _____

Now multiply the cross-section in square inches of your tree times $20.00. The answer that you obtain is called the Basic Value of your tree. What is the basic value of your tree? 6

In order to determine the true tree value you must find two more things: the Species Value and the Condition Value.

To find the Species Value, look on the chart called Species Value and find the name of your tree. You will notice that the trees are grouped by class numbers. Each class number has a percent species value. What is the percent Species Value of your tree? 7

Now let's try to find the Condition Value of your tree. The Condition Value is also expressed as a percentage just like the Species Value. To obtain the Condition Value you must use the chart called, "Condition Value of Trees." To use this chart, you must use your own judgement based on what your tree looks like. Follow the directions on the chart to get the Condition Value for your tree. What was the condition value for your tree? 8

Now let's list the three factors that you will use to determine the actual value of the tree. Copy your data in your notebook for these values.

Basic Value of tree = $

Species Value of tree = %

Condition Value of tree = %

Now use the following formula to determine the Actual Value of the tree you have been using: (On the next to last page is an example problem; study it before you work your problem). Actual Value = Basic Value x Species Value x Condition Value. Work your problem in your notebook. 10

This method of determining tree values was developed by the International Shade Tree Conference (I.S.T.C.). This system has been used by the courts to settle insurance claims, tax deductions and other legal settlements. This system is a good one because it is adaptable to all trees in any location in any physical condition.

TRUNK DIAMETERS AND AREA OF TRUNK CROSS-SECTIONS

Circumference in Feet	Trunk Diameter Inches	Cross-Section Area Sq. Inches	Circumference in Feet	Trunk Diameter Inches	Cross-Section Area Sq. Inches
.5	2	3.14	8.1	31	754.8
.8	3	7.07	8.4	32	804.3
1.0	4	12.57	8.6	33	855.3
1.3	5	19.64	8.9	34	907.9
1.6	6	28.27	9.2	35	962.1
1.8	7	38.49	9.4	36	1017.9
2.1	8	50.27	9.7	37	1075.2
2.4	9	63.62	10.0	38	1134.1
2.6	10	78.5	10.2	39	1194.6
2.9	11	95.0	10.5	40	1256.6
3.0	12	113.1	10.7	41	1320.3
3.4	13	132.7	11.0	42	1385.4
3.7	14	153.9	11.3	43	1452.2
3.9	15	176.7	11.5	44	1520.5
4.2	16	201.1	11.8	45	1590.4
4.5	17	227.0	12.0	46	1661.9
4.7	18	254.5	12.3	47	1734.9
5.0	19	283.5	12.6	48	1809.6
5.2	20	314.2	12.8	49	1885.7
5.5	21	346.4	13.1	50	1963.5
5.8	22	380.1	13.3	51	2042.8
6.0	23	415.5	13.6	52	2123.7
6.3	24	452.4	13.9	53	2206.2
6.5	25	490.9	14.1	54	2290.2
6.8	26	530.9	14.4	55	2375.8
7.1	27	572.6	14.7	56	2463.0
7.3	28	615.8	14.9	57	2551.8
7.6	29	660.5	15.2	58	2642.1
7.9	30	706.9	15.4	59	2734.0
			15.7	60	2827.4

SPECIES VALUE OF KAUKAUNA TREES

CLASS #1 - 100%

Sugar Maple
Red Maple
Ash
Bass Wood
Bur Oak
White Oak

CLASS #2 - 80%

Silver Maple
Locust
Birch
Willow
Red Oak

CLASS #3 - 60%

Cottonwood

CLASS #4 - 40%

Boxelder

CLASS #5 - 20%

Elm

Condition Value of Trees

To obtain Condition Values, add the numbers in Section A that represent your tree. Then add the numbers in Section B that represent your tree. Now subtract the Section B answer from the Section A answer. Finally, subtract this answer from 100% to obtain the Condition Value.

Section A

40% - Low Property Values

10% - Nearby non-living eyesores (rundown buildings, wires, telephone poles, etc.)

Tree's Appearance:

25% Dead and broken limbs and branches

15% Damaged trunk

20% Insect and disease damage

15% Trimming scars

10% Fire damage

25% Few branches

If nothing in Section A applies, then the tree Condition Value is automatically 100%.

Section B

5% Has beautiful flowers

10% Is a permanent part of landscape (part of courts, patios, etc.)

25% Historical significance

25% Rare type of tree

10% Adds unusual scenery to landscape (reflection in pools, shades walkways, etc.)

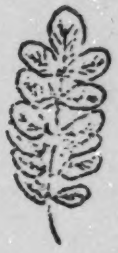
MOST COMMON TREES OF KAUKAUNA

SUGAR MAPLE

SILVER MAPLE

RED MAPLE

ASH



LOCUST

BOXELDER

ELM

BASSWOOD

BIRCH

WILLOW

BUR OAK

WHITE OAK

RED OAK

HAWTHORNE

COTTONWOOD

RVV.

EXPLORATORIUM 39

CHALLENGE

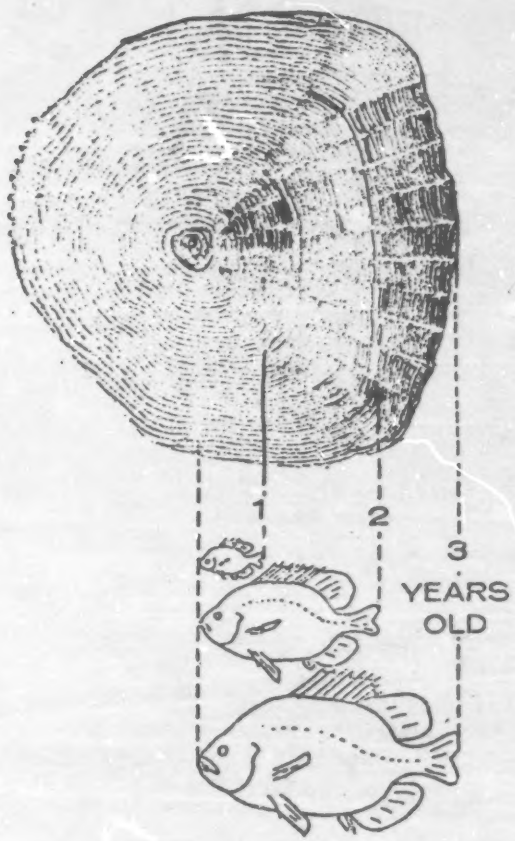
Determine the relationship between the length and age of a fish.

BACKGROUND

Just as rings tell the age of a tree, you can tell how old a fish is just by looking at a scale.

PRACTICE

Observe closely the bass scale on the slide on the table. Determine the age of the bass. (You should get about 11 years old).



An enlarged illustration of the scale from a 6-inch bluegill. Lines are drawn from the annuli. Annuli are similar to tree growth rings.

PROCEDURE

1. Obtain one scale from the side of each of the fish in the refrigerator.
2. Use a ruler to determine the length of the fish and microscope to determine age.
3. Calculate and compare the annual growth rate (inches/year) of the different species. What assumption is being made in making this comparison?
4. Clean up materials.

MATERIALS

2 Different species of fish
1 Ruler
Microscope

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EXPLORATORIUM 40

CHALLENGE

Understanding the Water Cycle

PROCEDURE

Water is one of the essential ingredients for life in both plants and animals. Write a short story which tells the life of a drop of water as it travels through the water cycle.

EXPLORATORIUM 41

CHALLENGE

Explore and tally life in a square foot of habitat

PROCEDURE

Go outside to a habitat of your choice

Designate your square foot plot--observe

Name the materials or objects found in your plot, and if possible, tally the frequency with which they occur.

Is there evidence that some materials have undergone change? Describe some of the changes.

Is there evidence of the presence of "man" in the area?

Which objects or phenomena lend themselves to further investigation?

Materials

4 foot long string
4 small stakes
Hand lens

EXPLORATORIUM 42

CHALLENGE

Find out how much air your lungs will hold.

PROCEDURE

1. Inhale and exhale, at least 3 times, trying to fill your lungs and empty them each time. Do this while standing.

2. Inhale as much air as you can, then exhale as much air as you can into the lung capacity bag. (Wash mouthpiece in sink before using!)

3. Carefully twist the end of the bag, lay it on a flat surface, press all the air to one end of the bag and read your capacity.

4. Open the bag, lay it on the table again and press out all of the air.

What would happen if?

1. You were to repeat the experiment, but this time, sitting up straight.

2. You were to repeat the experiment, but this time, sitting, slouched forward with elbows on knees.

3. You were to repeat the experiment, but this time, run in place, very rapidly, for 2 full minutes.

Materials

Lung capacity bags
Mouthpieces
Beaker of soapy water
Beaker of alcohol

EXPLORATORIUM 43

CHALLENGE

Check the effectiveness of your sense of touch. (WORK WITH A PARTNER).

BACKGROUND

Many types of life depend on their sense of touch for navigation, defense, and finding food. Except for people who are blind, touch is not a highly developed sense in human beings.

PROCEDURE

1st Trial - Study the eight round objects, touch them if you want to. Close your eyes and point a finger toward your partner. Your partner will hold each object against the tip of your finger for a maximum time of five seconds. See how many objects you can identify. Your partner can record the results on the scoresheet provided.

2nd Trial - Now try it again, only this time you are allowed to move the tip of your finger back and forth a distance of one-half inch on the object being held. Record the results. Now let your partner try it.

MATERIALS

Eight round objects
Scoresheets

EXPLORATORIUM 44

CHALLENGE

Observe an insect and find out five (5) things about him.

PROCEDURE

Use the collecting bottle to collect a live insect

Observe carefully using the magnifying bottle

List 5 things about him you did not know before in your notebook

Release insect to his habitat

EXPLORATORIUM 45

Challenge

Can you build a bird's nest?

Background

Birds are amazing architects. Their nests are much more than a pile of mud and sticks. You will gain a real appreciation of their abilities if you try to build one yourself.

Procedure

You have been given a variety of materials to work with. Using the guide book, find a bird's nest you would like to build and find out how much patience you have!

Materials

feathers
pine needles
twigs
milkweed
fibers
dirt
dried leaves
dried grasses

bird's nests
Peterson Guide to Bird's Nests
a lot of patience

EXPLORATORIUM 46

CHALLENGE

Is this "stuff" a solid or a liquid?

BACKGROUND

Below the lithosphere or solid crust of the earth is a semi-liquid or "plastic" area of rock about 250 kilometers thick called the asthenosphere. When earthquake (seismic) waves pass through this area of rock (asthenosphere), however, it acts more like it is a solid. Is is possible for a substance to act as a solid and a liquid at the same time?

PROCEDURE

1. Put the cornstarch in the cup. Add enough water to make a paste as you stir with your finger. It should be like thick oatmeal.
2. Remove the "stuff" and roll it into a ball in your hands. Put it on the table. It should "run" like thick milk.

Is it solid or liquid?

1. Pick the "stuff" up and roll it between your hands again. Does it act like a solid or a liquid when being rolled?
2. Put it on the table, does it act like a liquid or a solid?
3. Does the application of heat and pressure change the physical property of the material?
4. Do you think the heat and pressure of the earth could change the rocks in the asthenosphere?

How does velocity change a rocks characteristics?

1. Tap the mixture with your finger. Does it act like a solid or liquid?
2. Slowly push your finger into the mixture. Does it act like a solid or liquid?
3. How does speed change the property of the material?
4. Would the speed of a seismic wave be more like tapping your finger or slowly pushing your finger into the material?

MATERIALS

1/4 cup cornstarch
cup
water
toweling for cleaning up (don't put in sink, wrap in paper to dispose of)

EXPLORATORIUM 47

CHALLENGE

A Numbers Game

PROCEDURE

Here is a list of 24 highly special numbers. Each number has unique significance or application in our everyday lives. It has to do with stuff we all know or see or deal with fairly often.

After each number, there's a generous hint to its meaning to us - the characterizing phrase or label by which we know the number, but with only the initial letters of the key words supplied. The game is for you to complete each phrase by recognizing the number's significance.

1. 26 L. of the A.
2. 7 W. of the W.
3. 1001 A.N.
4. 12 S. of the Z.
5. 54 C. in a D. (with the J.)
6. 9 P. in the S.S.
7. 88 P.K.
8. 13 S. on the A.F.
9. 18 H. on a G.C.
10. 32 D.F. at which W.F.
11. 90 D. in a R.A.
12. 200 D. for P.G. in M.
13. 8 S. on a S.S.
14. 3 B.M. (S.H.T.R.)
15. 4 Q. in a G.
16. 24 H. in a D.
17. 1 W. on a U.
18. 5 D. in a Z.C.
19. 57 H.V.
20. 11 P. on a F.T.
21. 1000 W. that a P. is W.
22. 29 D. in F. in L.Y.
23. 64 S. on a C.
24. 40 D. and N. of the G.F.

Answers to numbers game

1. 26 letters of the alphabet
2. 7 wonders of the world
3. 1001 Arabean nights
4. 12 signs of the zodiac
5. 54 cards in the deck (with the jokers)
6. 9 planets in the solar system
7. 88 piano keys
8. 13 stripes on the American flag
9. 18 holes on a golf course
10. 32 degrees fahrenheit at which water freezes
11. 90 degrees in a right angle
12. 200 dollars for passing go in Monopoly
13. 8 sides on a stop sign
14. 3 blind mice (see how they run)
15. 4 quarts in a gallon
16. 24 hours in a day
17. 1 wheel on a unicycle
18. 5 digits in a zip code
19. 57 Heinz varieties
20. 11 players on a football team
21. 1000 words that a picture is worth
22. 29 days in February in leap year
23. 64 squares on a checkerboard
24. 40 days and nights of the great flood

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